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Karazoun

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(54) **METHODS AND APPARATUS TO INSPECT CHARACTERISTICS OF MULTICHANNEL AUDIO**

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G10L 19/018	(2013.01)
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G10L 21/055	(2013.01)
G10L 19/16	(2013.01)

(52) **U.S. Cl.**

CPC ***G10L 19/018*** (2013.01); ***G10L 19/008*** (2013.01); ***G10L 19/167*** (2013.01); ***G10L 21/055*** (2013.01)

(58) **Field of Classification Search**

CPC ... G10L 19/018; G10L 19/167; G10L 21/055; H04L 2209/608; G06F 2221/0733; G06T 1/0071; H04N 1/3232; H04N 1/32325; H04N 1/323331; H04N 21/8358

See application file for complete search history.

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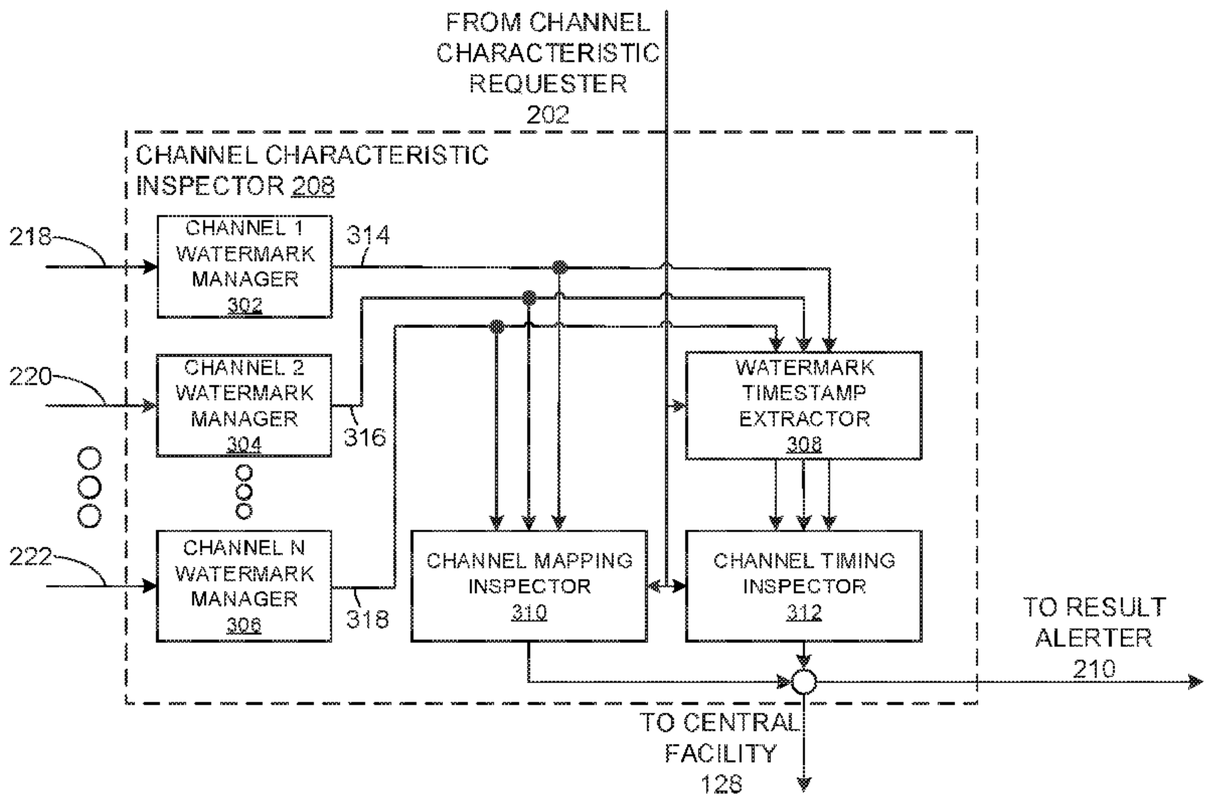
(57) **ABSTRACT**

Methods, apparatus, systems and articles of manufacture are disclosed for audio watermarking and, more particularly, methods and apparatus to inspect characteristics of multichannel audio. Example methods disclosed herein are further to obtain an audio subchannel of the multichannel audio signal, detect an embedded watermark in the audio subchannel of the multichannel audio signal, determine a characteristic of the audio subchannel of the multichannel audio signal based on the embedded watermark, and in response to determining an issue with the characteristic of the audio subchannel of the multichannel audio signal, distribute an alert.

20 Claims, 10 Drawing Sheets



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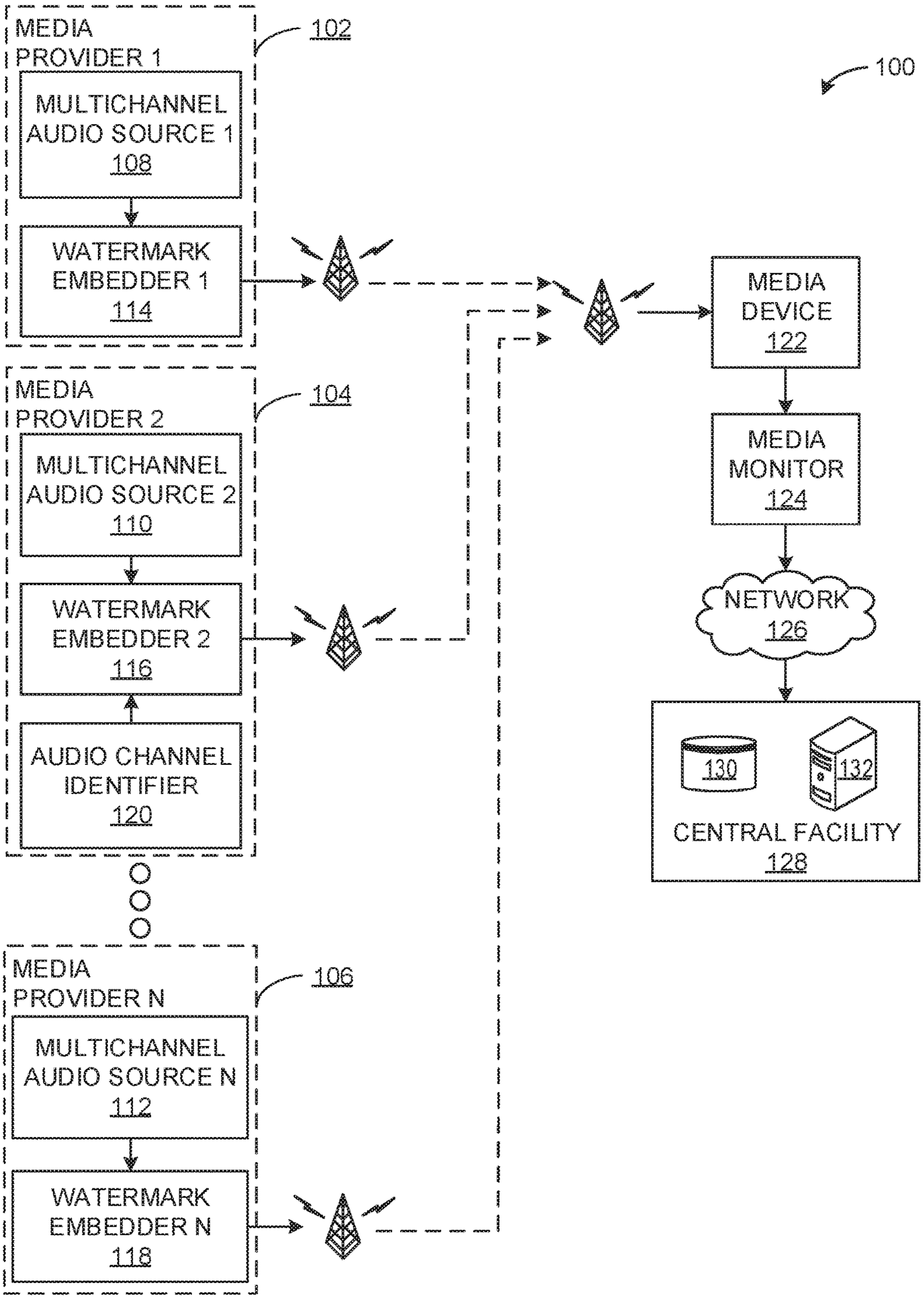

MEDIA PROVIDER 1
102
MULTICHANNEL AUDIO SOURCE 1 108
WATERMARK EMBEDDER 1 114
100
MEDIA DEVICE 122
MEDIA PROVIDER 2
104
MULTICHANNEL AUDIO SOURCE 2 110
WATERMARK EMBEDDER 2 116
AUDIO CHANNEL IDENTIFIER 120
MEDIA MONITOR 124
NETWORK 126
130
132
CENTRAL FACILITY 128
MEDIA PROVIDER N
106
MULTICHANNEL AUDIO SOURCE N 112
WATERMARK EMBEDDER N 118

FIG. 1

FIG. 2

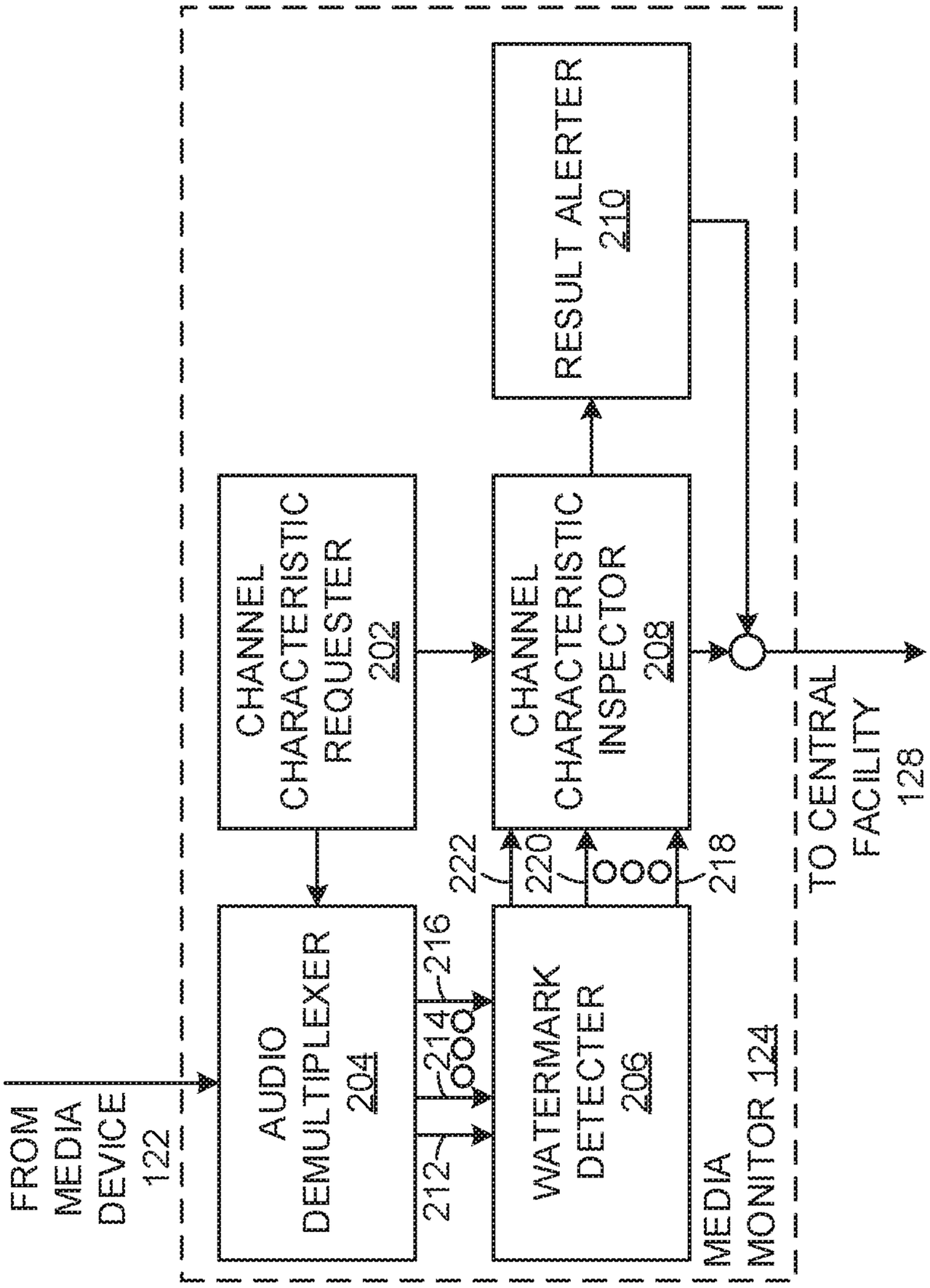
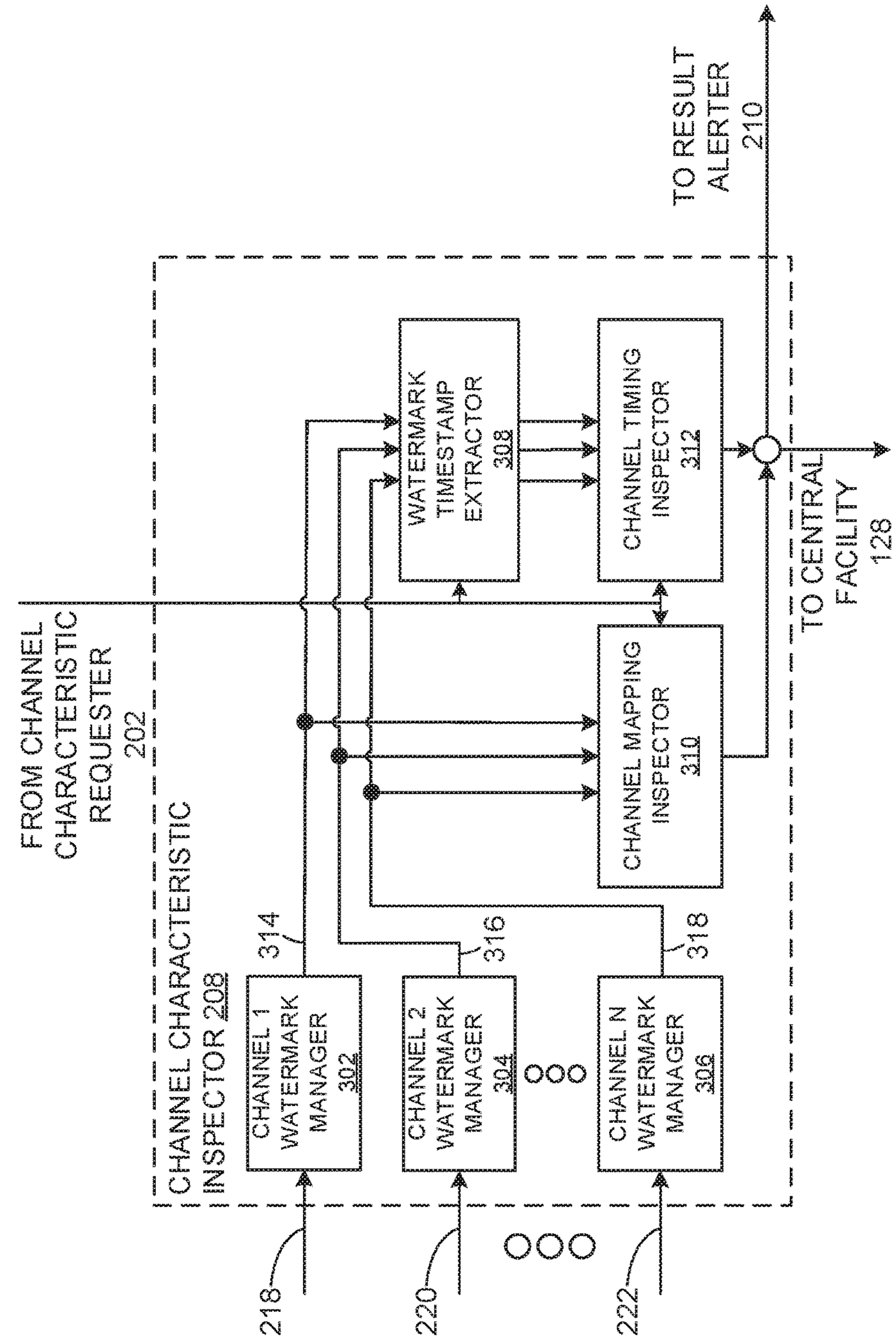

MEDIA MONITOR 124
FROM MEDIA DEVICE 122
AUDIO DEMULTIPLEXER 204
WATERMARK DETECTER 206
CHANNEL CHARACTERISTIC REQUESTER 202
CHANNEL CHARACTERISTIC INSPECTOR 208
RESULT ALERTER 210
TO CENTRAL FACILITY 128
212
214
216
218
220
222

FIG. 3


CHANNEL CHARACTERISTIC INSPECTOR 208
FROM CHANNEL CHARACTERISTIC REQUESTER 202
TO RESULT ALERTER 210
TO CENTRAL FACILITY 128
WATERMARK TIMESTAMP EXTRACTOR 308
CHANNEL TIMING INSPECTOR 312
CHANNEL MAPPING INSPECTOR 310
CHANNEL 1 WATERMARK MANAGER 302
CHANNEL 2 WATERMARK MANAGER 304
CHANNEL N WATERMARK MANAGER 306
314
316
318
218
220
222

400

402 MEDIA PROVIDER	404 CHANNEL MAPPING RESULT	406 CHANNEL TIMING RESULT
408 CBS 2 WBBM	AUDIO IS OK	CHANNEL 2 DELAY
410 NBC 5 WMAQ	CHANNEL MAPPING ISSUE	AUDIO IS OK
412 ABC 7 WLS	AUDIO IS OK	AUDIO IS OK
414 FOX 32 WFLD	AUDIO IS OK	CHANNEL N DELAY
416 MY 50 WPWR	LEFT CHANNEL MAPPING ISSUE	AUDIO IS OK
418 WGN 9	AUDIO IS OK	NOT INSPECTED
420 PBS 11 WTTW	NOT INSPECTED	AUDIO IS OK

FIG. 4

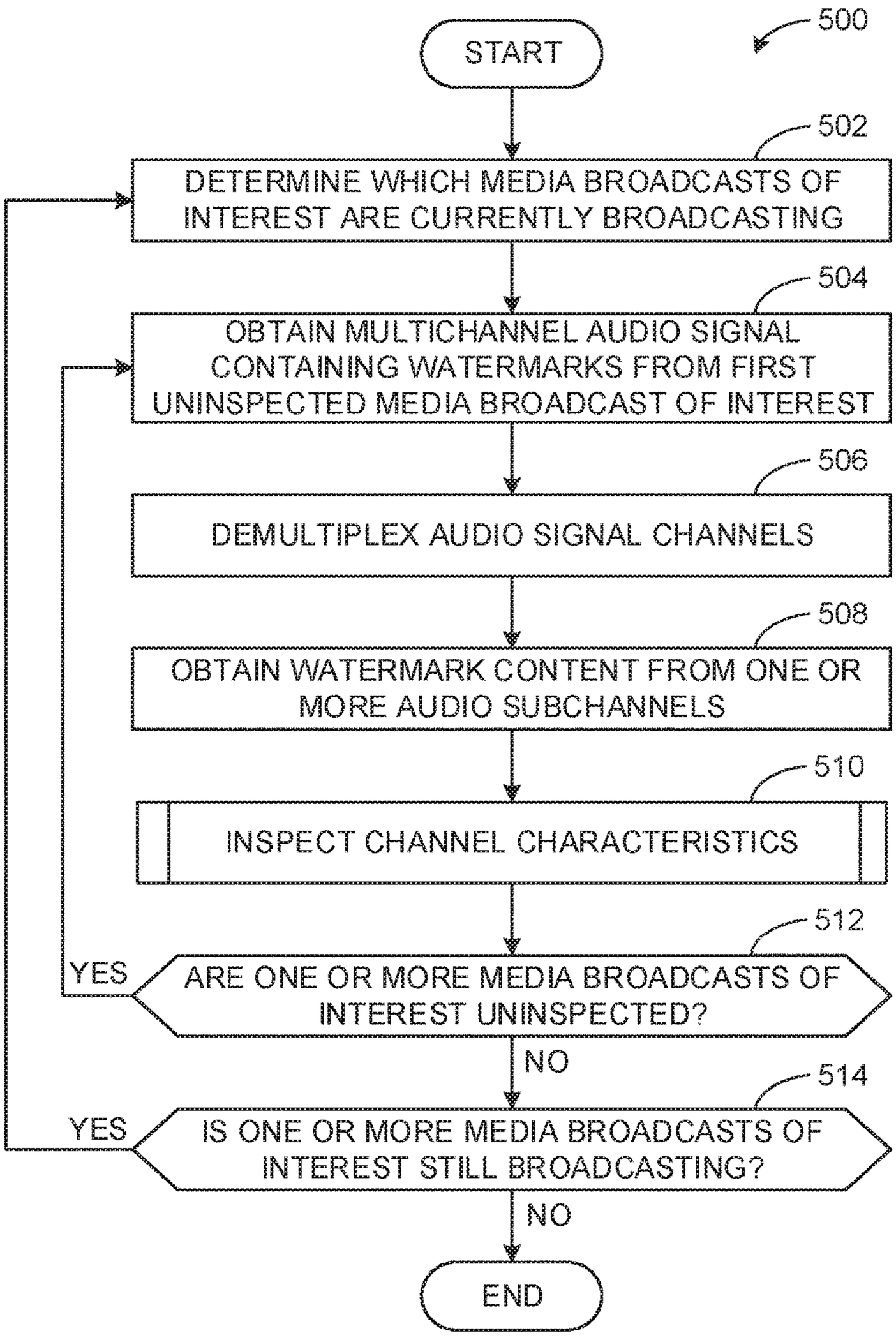

500
START
502
DETERMINE WHICH MEDIA BROADCASTS OF INTEREST ARE CURRENTLY BROADCASTING
504
OBTAIN MULTICHANNEL AUDIO SIGNAL CONTAINING WATERMARKS FROM FIRST UNINSPECTED MEDIA BROADCAST OF INTEREST
506
DEMULTIPLEX AUDIO SIGNAL CHANNELS
508
OBTAIN WATERMARK CONTENT FROM ONE OR MORE AUDIO SUBCHANNELS
510
INSPECT CHANNEL CHARACTERISTICS
512
YES
ARE ONE OR MORE MEDIA BROADCASTS OF INTEREST UNINSPECTED?
NO
514
YES
IS ONE OR MORE MEDIA BROADCASTS OF INTEREST STILL BROADCASTING?
NO
END

FIG. 5

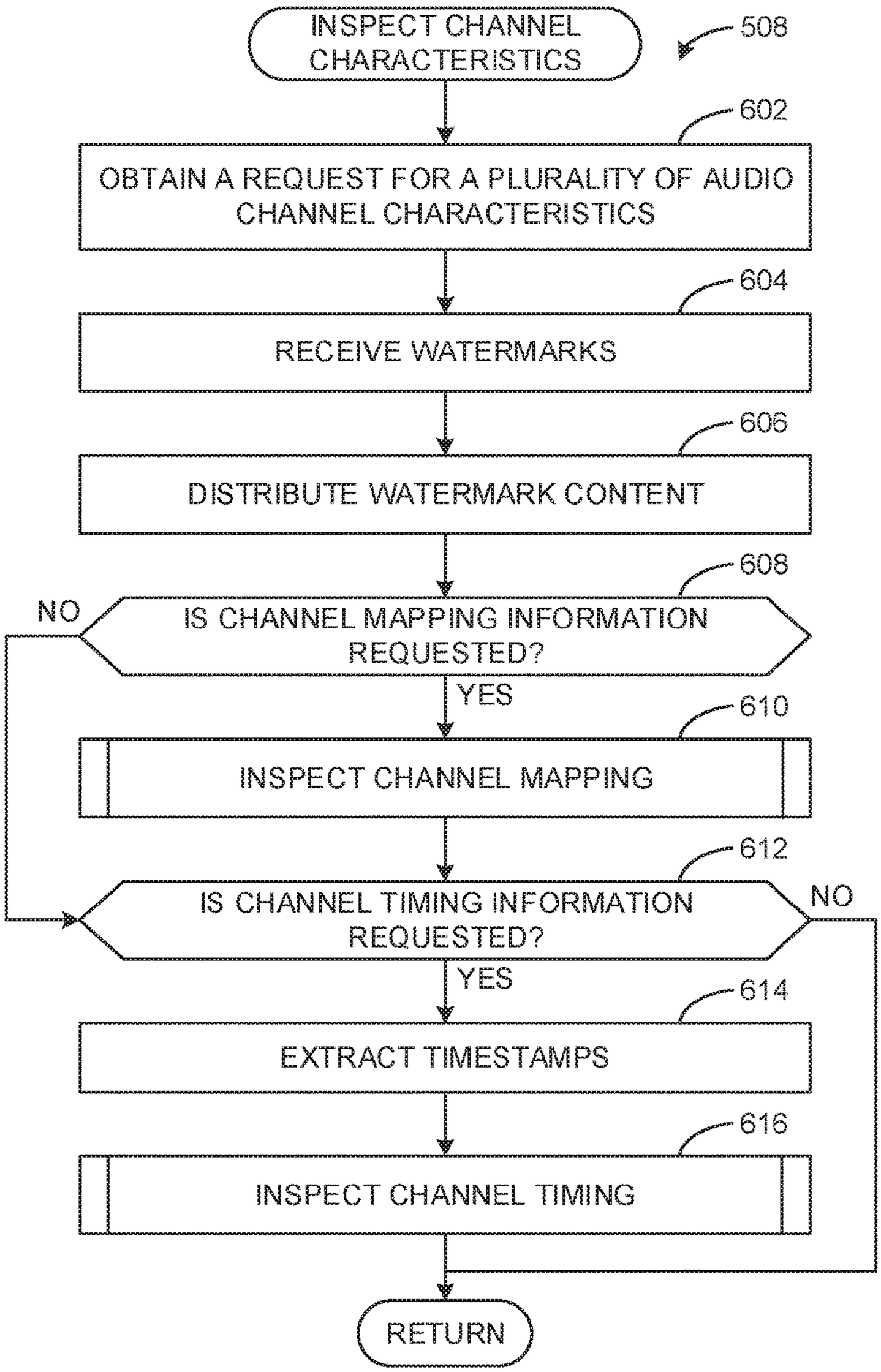

INSPECT CHANNEL CHARACTERISTICS
508
602
OBTAIN A REQUEST FOR A PLURALITY OF AUDIO CHANNEL CHARACTERISTICS
604
RECEIVE WATERMARKS
606
DISTRIBUTE WATERMARK CONTENT
608
IS CHANNEL MAPPING INFORMATION REQUESTED?
NO
YES
610
INSPECT CHANNEL MAPPING
612
IS CHANNEL TIMING INFORMATION REQUESTED?
NO
YES
614
EXTRACT TIMESTAMPS
616
INSPECT CHANNEL TIMING
RETURN

FIG. 6

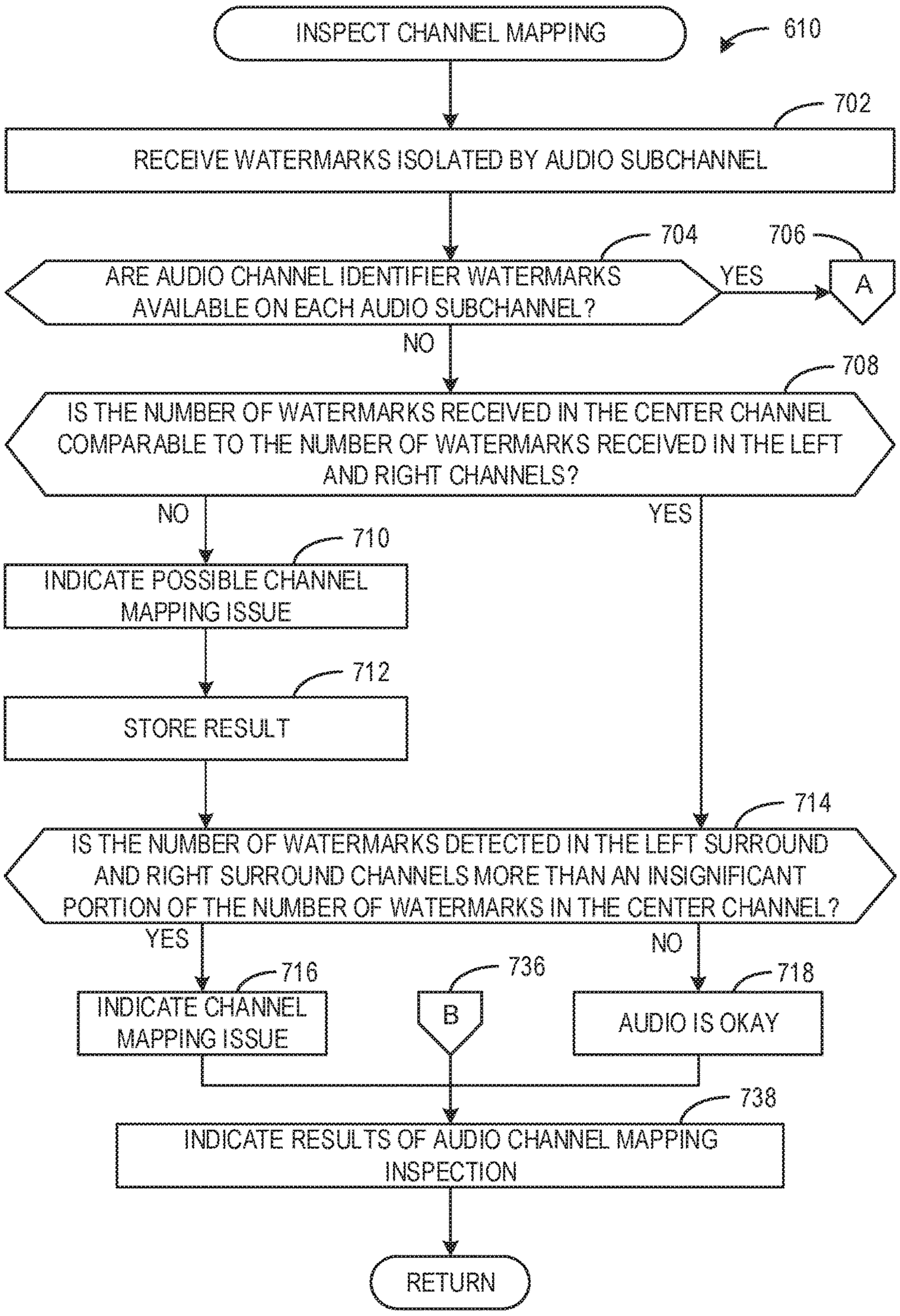

INSPECT CHANNEL MAPPING
610
RECEIVE WATERMARKS ISOLATED BY AUDIO SUBCHANNEL
702
ARE AUDIO CHANNEL IDENTIFIER WATERMARKS AVAILABLE ON EACH AUDIO SUBCHANNEL?
704
YES
706
A
NO
IS THE NUMBER OF WATERMARKS RECEIVED IN THE CENTER CHANNEL COMPARABLE TO THE NUMBER OF WATERMARKS RECEIVED IN THE LEFT AND RIGHT CHANNELS?
708
NO
YES
INDICATE POSSIBLE CHANNEL MAPPING ISSUE
710
STORE RESULT
712
IS THE NUMBER OF WATERMARKS DETECTED IN THE LEFT SURROUND AND RIGHT SURROUND CHANNELS MORE THAN AN INSIGNIFICANT PORTION OF THE NUMBER OF WATERMARKS IN THE CENTER CHANNEL?
714
YES
NO
INDICATE CHANNEL MAPPING ISSUE
716
B
736
AUDIO IS OKAY
718
INDICATE RESULTS OF AUDIO CHANNEL MAPPING INSPECTION
738
RETURN

FIG. 7A

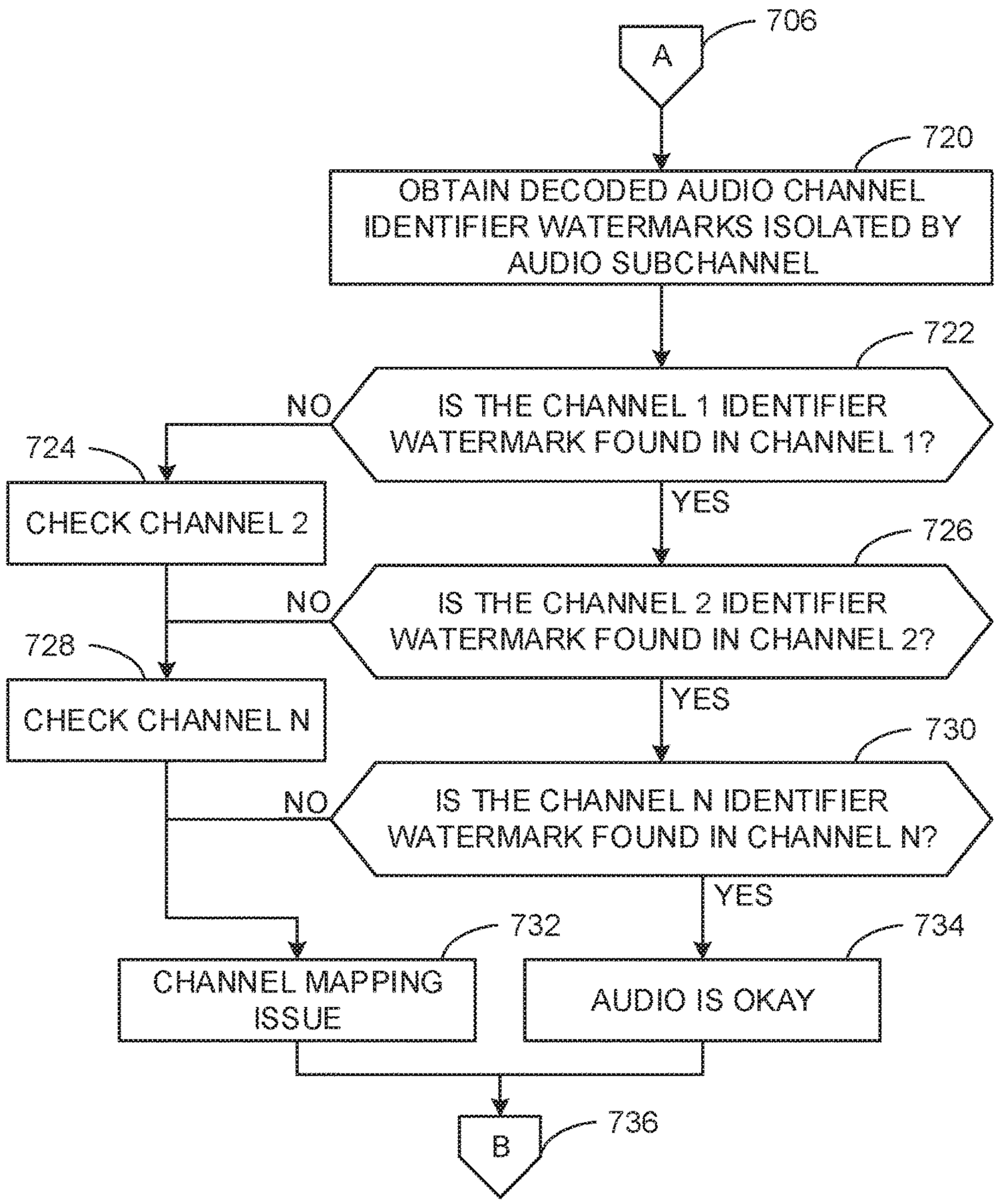

706
A
720
OBTAIN DECODED AUDIO CHANNEL IDENTIFIER WATERMARKS ISOLATED BY AUDIO SUBCHANNEL
722
NO
IS THE CHANNEL 1 IDENTIFIER WATERMARK FOUND IN CHANNEL 1?
724
CHECK CHANNEL 2
YES
726
NO
IS THE CHANNEL 2 IDENTIFIER WATERMARK FOUND IN CHANNEL 2?
728
CHECK CHANNEL N
YES
730
NO
IS THE CHANNEL N IDENTIFIER WATERMARK FOUND IN CHANNEL N?
YES
732
CHANNEL MAPPING ISSUE
734
AUDIO IS OKAY
B
736

FIG. 7B

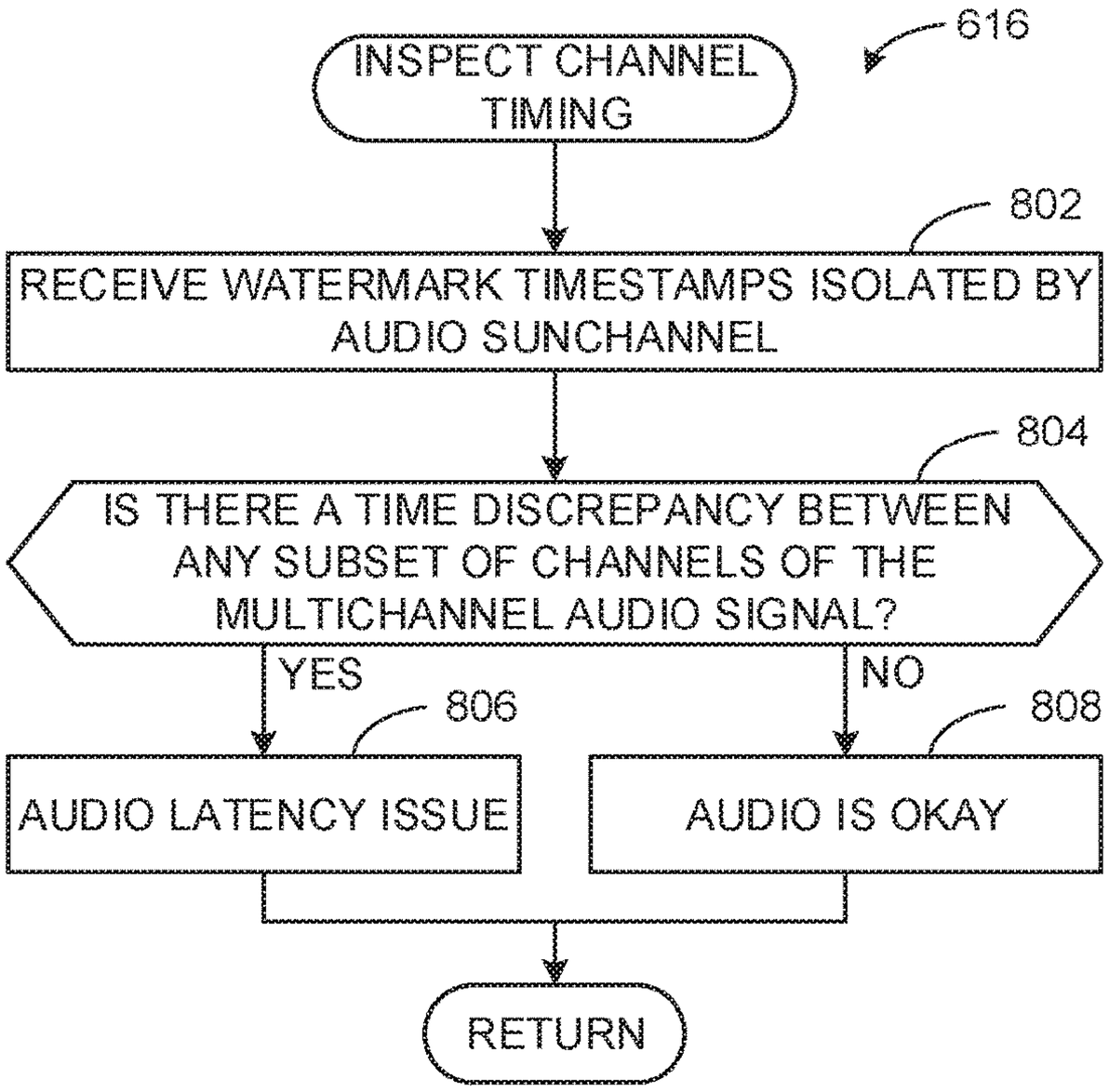

INSPECT CHANNEL TIMING
616
802
RECEIVE WATERMARK TIMESTAMPS ISOLATED BY AUDIO SUNCHANNEL
804
IS THERE A TIME DISCREPANCY BETWEEN ANY SUBSET OF CHANNELS OF THE MULTICHANNEL AUDIO SIGNAL?
YES
NO
806
808
AUDIO LATENCY ISSUE
AUDIO IS OKAY
RETURN

FIG. 8

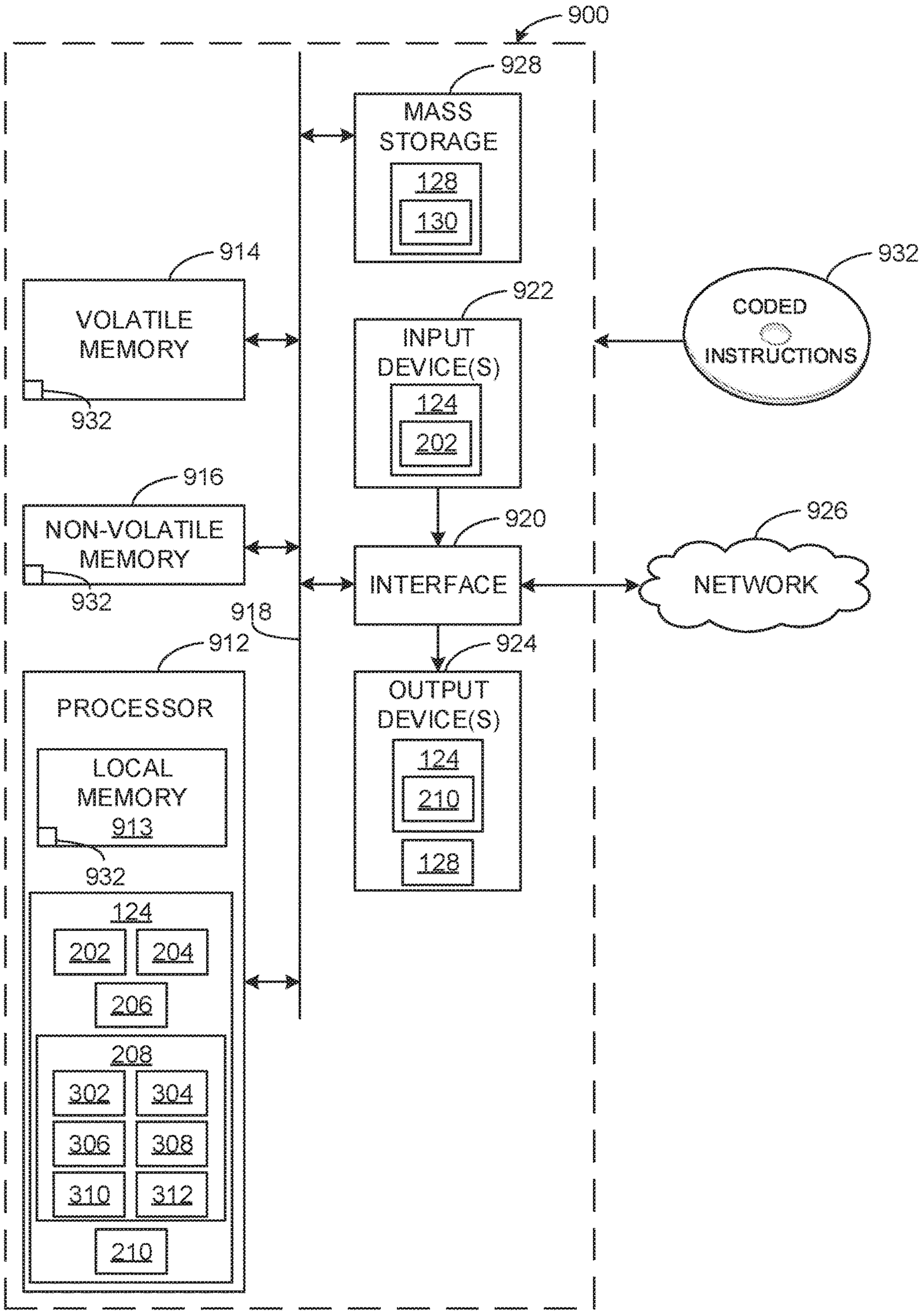

900
928
MASS STORAGE
128
130
914
VOLATILE MEMORY
932
922
INPUT DEVICE(S)
124
202
932
CODED INSTRUCTIONS
916
NON-VOLATILE MEMORY
932
920
926
INTERFACE
NETWORK
918
912
924
PROCESSOR
LOCAL MEMORY
913
932
OUTPUT DEVICE(S)
124
210
128
124
202
204
206
208
302
304
306
308
310
312
210

FIG. 9

METHODS AND APPARATUS TO INSPECT CHARACTERISTICS OF MULTICHANNEL AUDIO

FIELD OF THE DISCLOSURE

This disclosure relates generally to audio watermarking and, more particularly, methods and apparatus to inspect characteristics of multichannel audio.

BACKGROUND

Audio watermarks are embedded into audio signals to carry hidden data that can be used in a wide variety of practical applications. For example, to monitor the distribution of media content and/or advertisements, such as television broadcasts, radio broadcasts, streamed multimedia content, etc., audio watermarks carrying media identification information can be embedded in the audio portion(s) of the distributed media. During a media presentation, the audio watermark(s) embedded in the audio portion(s) of the media can be detected by a watermark detector and decoded to obtain the media identification information identifying the presented media.

In some examples, the audio source provided to a media device is a multichannel audio signal. In such examples, watermarks are embedded in specific subchannels of the multichannel audio signal by the media provider. However, a media provider embedding watermarks into improper audio subchannels or improperly synchronizing the timing of the embedded watermarks across audio subchannels can lead to one or more undesirable results, including the watermarks no longer being detectable by detection hardware or the watermarks becoming perceptible to the end user. With the current state of the technology, issues with audio channel mapping and timing can go undetected and therefor unaddressed for extended periods of time, which can have an adverse effect on the ratings of programs with improperly embedded audio watermarks.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an example environment in which a system for inspecting channel characteristics of a multichannel audio signal constructed with the teachings of this disclosure operates.

FIG. **2** is a block diagram of an example implementation of the media monitor of FIG. **1**.

FIG. **3** is a block diagram of an example implementation of the channel characteristic inspector of the media monitor system of FIG. **2**.

FIG. **4** is an example table showing results determined and output by the channel characteristic inspector of FIG. **3**.

FIG. **5** is a flowchart representative of example machine-readable instructions that may be executed to implement the example media monitor of FIGS. **1** & **2**.

FIG. **6** is a flowchart representative of example machine-readable instructions that may be executed to implement the example channel characteristic inspector of FIGS. **2** & **3**.

FIG. **7**A-**7**B collectively form a flowchart representative of example machine-readable instructions that may be executed to implement the example channel mapping inspector of FIG. **3**.

FIG. **8** is a flowchart representative of example machine-readable instructions that may be executed to implement the example channel timing inspector of FIG. **3**.

FIG. **9** is a block diagram of an example processor platform capable of executing the instructions of FIGS. **5**, **6**, **7**A, **7**B, and/or **8** to implement the example system of FIG. **1**.

DETAILED DESCRIPTION

Audio watermarking is a technique used to identify media such as television broadcasts, radio broadcasts, advertisements (television and/or radio), downloaded media, streaming media, prepackaged media, etc. Existing audio watermarking techniques identify media by embedding one or more audio codes (e.g., one or more watermarks), such as media identifying information and/or an identifier that may be mapped to media identifying information, into an audio and/or video component. In some examples, the audio or video component is selected to have a signal characteristic sufficient to hide the watermark. As used herein, the terms "code" or "watermark" are used interchangeably and are defined to mean any identification information (e.g., an identifier) that may be inserted or embedded in the audio or video of media (e.g., a program or advertisement) for the purpose of identifying the media or for another purpose such as tuning (e.g., a packet identifying header) or characteristic inspection. As used herein, the terms "encode" or "embed" are used interchangeably and are defined to mean any method of inserting a code or watermark into the audio or video portion of a media presentation (e.g., a program or advertisement). As used herein "media" refers to audio and/or visual (still or moving) content and/or advertisements. To identify watermarked media, the watermark(s) are extracted and used to access reference watermarks that are mapped to media identifying information.

The aforementioned embedding of watermarked identification information in media is often performed at or on the behalf of a media provider. Such embedding relies on cooperation with media providers, and also, in some examples, relies upon media providers properly embedding watermarks into one or more subchannels of a multichannel audio signal. As used herein, "subchannel" and "channel" are used interchangeably and are defined to mean any individual audio signal to be distributed to an individual audio output source of a multichannel audio signal. Several examples of common multichannel audio signals include 2-channel stereo, 3-channel stereo, and 5.1 channel surround sound. The channels of a 2-channel stereo are referred to as Left (L) and Right (R), 3-channel stereo adds a Center channel (C), and 5.1 channel surround sound further adds Left Surround (LS), Right Surround (RS), and Low Frequency (LFE) channels. As used herein, "multichannel audio signal" and "multichannel audio" are used interchangeably and are defined to mean audio signal containing two or more audio subchannels.

The embedding of watermarks is further reliant upon the media provider properly configuring the mapping (i.e., which subchannels of a multichannel audio signal receive embedded watermarks and which subchannels do not) of the watermark encoders. When properly encoded, audio watermarks will be distributed substantially equally between the Left, Right, and Center audio channels. Conversely, an insignificant quantity of watermarks will be distributed in the Left Surround, Right Surround, and Low Frequency audio channels. However, there are many example improper channel mappings that could be configured by the media provider. For example, in mapping 6 channels (e.g., 5.1 surround sound), the encoder mapping could be configured as 3 pairs of 2-channel stereo or 2 pairs of 3-channel stereo.

In the aforementioned cases, watermarks would appear on all 6 subchannels of the multichannel audio signal. Alternatively, the example encoder could map 2 pairs of LS, RS, and LFE audio channels to a 6 channel audio signal. In this case, watermarks would not appear in any subchannels of the example multichannel audio signal. All cases above will directly impact the detectability of one or more watermark(s) by audio watermarking detection devices and are meant as examples, not limiting the number of improper audio channel mappings that could exist.

The embedding of watermarks further relies upon media providers embedding watermarks at the proper instants in time. In order to ensure proper decoding of watermarks when embedding one or more watermark(s) into two or more subchannels of a multichannel audio signal, subchannels containing watermarks must be synchronized in time (i.e., contain synchronized timestamps). When one or more watermark(s) in two or more subchannels are properly synchronized in time, the timing of the one or more watermark(s) will not negatively impact the decoding of the more or more watermark(s). Alternately, when one or more watermark(s) in two or more subchannels are not properly synchronized in time, a potential for one or more watermark(s) embedded on two or more subchannels of a multichannel audio signal to interfere with one another exists. Additionally, as used herein, a "channel pair" refers to any two subchannels of a multichannel audio signal. In this alternative example, the possibility exists that the described interference will cause one or more watermark(s) to be undetectable by an example watermark detector and/or become audible to an example audience of the presented media.

Example methods, apparatus, and articles of manufacture disclosed herein inspect characteristics of multichannel audio signals presented at media devices. Such media devices may include, for example, set-top boxes (STB), cable and/or satellite receivers, Internet-enabled televisions, personal computers, Internet-enabled mobile handsets (e.g., a smartphone), video game consoles (e.g., Xbox®, PlayStation®), tablet computers (e.g., an iPad®), digital media players (e.g., a Roku® media player, a Slingbox®, etc.), etc. In some examples, inspection information is aggregated to determine the presence of proper and/or improper characteristics, in some such examples including at least one of a channel mapping characteristic and a channel timing characteristic, of watermarks embedded in multichannel audio signals. In other such examples, the presence of improper characteristics of watermarks embedded in multichannel audio signals is distributed as an alert. In examples disclosed herein, monitoring information includes, but is not limited to, media identifying information (e.g., media-identifying metadata, codes, signatures, watermarks, and/or other information that may be used to identify presented media), audio subchannel identification information (e.g., audio subchannel identifying watermarks, codes, signatures, etc.), application usage information (e.g., an identifier of an application, a time and/or duration of use of the application, a rating of the application, etc.), and/or user-identifying information (e.g., demographic information, a user identifier, a panelist identifier, a username, etc.).

Some example methods further include using watermarks designated for media monitoring and/or crediting to inspect the channel mapping of watermarks embedded in one or more subchannel(s) of a multichannel audio signal and/or the channel timing of watermarks embedded in two or more subchannels of a multichannel audio signal. In some such example methods, to inspect the channel mapping of a multichannel audio signal, the quantity of embedded watermarks detected in each subchannel are compared. For example, for 5.1 channel surround sound, if the quantity of embedded watermarks detected in one or more of the LFE, LS, and/or RS audio channel(s) is significant when compared to the quantity of embedded watermarks detected in the C channel, indicating that the channel mapping is improper. Alternatively, if the quantity of embedded watermarks detected in the LFE, LS, and RS audio channels is insignificant when compared to the quantity of embedded watermarks detected in the C channel, indicating that the channel mapping is correct. In some such examples, "insignificant" can be further defined to mean less than 1% and "significant" can be further defined to mean greater than 1%.

Additionally or alternatively, if the number of embedded watermarks detected in the C channel is not approximately equal to the L, and R channels, indicating that a possible audio channel mapping issue exists. Alternatively, if the number of embedded watermarks detected in the C channel is approximately equal to the L, and R audio channels, indicating that the channel mapping may be correct. Additionally or alternatively, any combination or permutation of the above examples may be employed to inspect the channel mapping of a multichannel audio signal. Additionally, the above disclosed examples are not meant to be limiting to the scope of the coverage of this patent. On the contrary, this patent covers all examples of using embedded watermarks to inspect channel mapping of a multichannel audio signal. In some such examples, "approximately" can be further defined to mean within a tolerance of 50% to 90% inclusive.

Some example methods further include inspecting the channel mapping of a multichannel audio signal when audio channel identifier watermarks are available. In such examples, with cooperation from media providers, additional watermarking information can be embedded into one or more subchannel(s) of a multichannel audio signal. Further, the additional watermarking information embedded would be the intended audio subchannel for the watermark to be embedded in. For example, if a L audio channel watermark identifier is detected on the L audio channel, a R audio channel watermark identifier is detected on the R audio channel, and so on for each subchannel of a multichannel audio signal, indicating that the channel mapping is correct. Alternatively, if one or more of the audio channel identifier watermark(s) is(are) not detected on the proper subchannel(s) (i.e., a C audio channel watermark identifier is detected on the R audio channel or the LS audio channel watermark identifier is detected on the R audio channel, etc.), indicating that the channel mapping is improper.

Additionally or alternatively, example methods further include detecting the timing of one or more embedded watermark(s) embedded in two or more audio subchannels of a multichannel audio signal. In such examples, timestamp(s) from one or more embedded watermark(s), intended to be embedded at a similar time, in two or more audio subchannels of a multichannel audio signal are extracted. Once extracted, the timestamp(s) of one or more embedded watermark(s) from two or more subchannels of a multichannel audio signal are compared. In some examples, if a time discrepancy exists for any one or more watermark(s) intended to be embedded at a similar time from two or more audio subchannels of a multichannel audio signal, indicating that an audio subchannel timing issue exists. Alternatively, if all of one or more watermark(s) intended to be embedded at a similar time from two or more audio subchannels of a multichannel audio signal contain similar timestamps, indicating that the channel timing of the inspected audio subchannels is correct. In some such

examples, "similar" can be further defined to mean within a tolerance of 0.0833 milliseconds.

Additionally or alternatively, combinations of the foregoing channel characteristic inspection examples for multichannel audio signals are also possible, as described in further detail below.

Turning to the figures, a block diagram of example system **100** for distributing audio/media and inspecting characteristics of multichannel audio signals includes media providers **102**, **104**, and **106**. The media providers **102**, **104**, and **106** further include multichannel audio sources **108**, **110**, and **112**, and watermark embedders **114**, **116**, and **118**. Alternatively, the example media provider **104** also includes an audio channel identifier **120** embedded by watermark embedder **116**. The example system **100** further includes a media device **122**, a media monitor **124**, a network **126**, and a central facility **128**. The central facility, for example, includes a data store **130**, and a processor **132**.

The example media provider(s) **102**, **104**, and/or **106** of the illustrated example of FIG. **1** correspond(s) to any one or more media provider(s) capable of providing media for presentation via the media device **122**. The media distributed by the media provider(s) **102**,**104**, and/or **106** can provide any type(s) of media containing a multichannel audio signal. Additionally, the media can correspond to live media, streaming media, broadcast media, stored media, on-demand content, etc.

The example multichannel audio source(s) **108**, **110**, and/or **112** of the illustrated example of FIG. **1** correspond(s) to any audio source containing two or more audio subchannels that may be presented using two or more example speakers. Each of the audio subchannels, prior to any signal processing, is combined in one signal. Examples of multichannel audio sources include 2-channel stereo (L and R channels), 2.1 channel stereo (L and R and LFE channels), 3-channel stereo (L, R, and C channels), and 5.1 channel surround (L, R, C, LS, RS, and LFE channels). Note that the above examples are not meant to be limiting, and that any audio signal containing two or more subchannels can be classified as a multichannel audio signal.

The example watermarks embedder(s) **114**, **116**, and/or **118** of the illustrated example of FIG. **1** embed one or more media identifying watermark(s) into one or more subchannel(s) of the multichannel audio source(s) **108**, **110**, and/or **112** distributed from the media provider(s) **102**, **104**, and/or **106**. In one example of proper audio subchannel watermark embedding, the example watermark embedder(s) **114**, **116**, and/or **118** will embed a similar quantity of watermarks, synchronized in time, to the example L, R, and C channels, and will embed an insignificant quantity of watermarks in the example LS, RS, and LFE channels of an example 5.1 surround sound mapping of the example multichannel audio source(s) **108**, **110**, and/or **112**.

Additionally or alternatively, in an example of improper audio subchannel watermark embedding, the example watermark embedder(s) **114**, **116**, and/or **118** will embed a dissimilar amount of watermarks, which may be out of synchronization in time, in the example L, R, and C audio channels and/or will embed a substantially significant quantity of watermarks in the example LS, RS, and/or LFE channels of an example 5.1 surround sound mapping of the example multichannel audio source(s) **108**, **110**, and/or **112**. Note that the above examples are not meant to be limiting, and that any combination and/or permutation of the foregoing audio channel watermark characteristics are covered in the scope of this patent.

The example audio channel identifier **120** of the illustrated example of FIG. **1** embeds one or more additional watermark(s) into one or more subchannel(s) of the multichannel audio source **110** from the media provider **104**. In such an example, the additional watermark(s) contain(s) information identifying the proper audio subchannel for one or more embedded watermark(s) in one or more audio subchannel(s) of the multichannel audio source **110**. Thus, the one or more additional watermark(s) embedded into one or more subchannel(s) of the multichannel audio source **110** from media provider **104** may be used to, in one such example, determine that one or more content identifying watermark(s) embedded into one or more audio subchannel(s) are each embedded into the proper one or more audio channel(s).

Additionally or alternatively, the one or more additional watermark(s) embedded into one or more subchannel(s) of the multichannel audio source **110** from media provider **104** may be used, in another such example, to determine that one or more content identifying watermark(s) embedded into one or more audio subchannel(s) are embedded in the improper (i.e., the Left channel audio watermark of the multichannel audio source **110** is embedded in a Right audio channel of the multichannel audio source **110**) one or more audio subchannel(s).

The example media device **122** of the illustrated example shown in FIG. **1** is a device that receives media from the example media provider(s) **102**, **104**, and/or **106** for presentation. In some examples, the media device **122** is capable of directly presenting media (e.g., via a display) while, in other examples, the media device **122** presents the media on separate media presentation equipment (e.g., speakers, a display, etc.). Thus, as used herein "media devices" may or may not be able to present media without assistance from a second device. Media devices are typically consumer electronics. For example, if the media device **122** is a personal computer such as a laptop computer, and thus, is capable of directly presenting media (e.g., via an integrated and/or connected display and speakers). While in the above example a personal computer is described, any other type(s) and/or number(s) of media device(s) may additionally or alternatively be used. For example, set-top boxes (STB), cable and/or satellite receivers, Internet-enabled mobile handsets (e.g., a smartphone, an iPod®, etc.), video game consoles (e.g., Xbox®, PlayStation® 4, etc.), tablet computers (e.g., an iPad®, a Motorola™ Xoom™, etc.), digital media players (e.g., a Roku® media player, a Slingbox®, a Tivo®, etc.), smart televisions, desktop computers, laptop computers, servers, etc. may additionally or alternatively be used.

The example media monitor **124** of the illustrated example shown in FIG. **1**, described in greater detail below, inspects one or more characteristic(s) of the example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** and distributed by the example media provider(s) **102**, **104**, and/or **106**. For example, the media monitor **124** can inspect a channel timing for one or more pair(s) of audio subchannels of the example multichannel audio source(s) **108**, **110**, and/or **112**, and inspect a channel mapping of the example multichannel audio source(s) **108**, **110**, and/or **112** using audio watermarks embedded for the purpose of content identification and/or crediting by the example watermark embedder(s) **114**, **116**, and/or **118**.

Additionally or alternatively, the media monitor **124** can inspect a channel timing for one or more pair(s) of subchannels of the multichannel audio source **110**, and inspect a

channel mapping of the multichannel audio source **110** using one or more audio watermark(s) containing audio channel identifier **120** embedded by the watermark embedder **116**.

Additionally or alternatively, the media monitor **124** can inspect fewer than two channel characteristics of the example multichannel audio source(s) **108**, **110**, and/or **112**. In some such examples, the media monitor **124** can inspect channel timing, but not channel mapping. Additionally or alternatively, the media monitor **124** can inspect channel mapping, but not channel timing. Additionally or alternatively, the media monitor **124** can inspect neither of channel timing and channel mapping.

The example network **126** of the illustrated example of FIG. **1** is the Internet. However, the example network **126** may be implemented using any suitable wired and/or wireless network(s) including, for example, one or more data buses, one or more Local Area Networks (LANs), one or more wireless LANs, one or more cellular networks, one or more private networks, one or more public networks, etc. The example network **126** enables the example media monitor **124** to be in communication with the example central facility **128**. As used herein, the phrase "in communication," including variances thereof, encompasses direct communication and/or indirect communication through one or more intermediary components and does not require direct physical (e.g., wired) communication and/or constant communication, but rather includes selective communication at periodic or aperiodic intervals, as well as one-time events.

The example central facility **128** of the illustrated example of FIG. **1** is a server that collects and processes one or more inspected characteristic(s) of multichannel audio signals from the media monitor **124** to create one or more report(s), described in further detail below, on the inspected characteristics for one or more of the example multichannel audio source(s) **108**, **110**, and/or **112**. Further, in some examples, the central facility **128** can analyze the inspection results of characteristics of multichannel audio signals of the example multichannel audio source(s) **108**, **110**, and/or **112**. For example, a report on media provider **102** could state that both the audio channel mapping and the audio channel timing are correct.

Alternatively, a report on media provider **102** could state that an audio channel mapping issue exists, but the audio channel timing is correct. Alternatively, a report on media provider **102** could state that the audio channel mapping is correct, but a time discrepancy exists between two or more audio subchannels of the multichannel audio signal. Alternatively, a report on media provider **102** could state that an audio channel mapping issue exists and a time discrepancy exists between two or more subchannels of the multichannel audio signal.

In the illustrated example of FIG. **1**, the central facility **128** includes the data store **130** to record data (e.g., obtained information, generated messages, generated reports, etc.). The data store **130** may be implemented by a volatile memory (e.g., a Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM), etc.) and/or a non-volatile memory (e.g., flash memory). The data store **130** may additionally or alternatively be implemented by one or more double data rate (DDR) memories, such as DDR, DDR2, DDR3, DDR4, mobile DDR (mDDR), etc. The data store **130** may additionally or alternatively be implemented by one or more mass storage devices such as hard disk drive(s), compact disk drive(s) digital versatile disk drive(s), etc. While in the illustrated example the data store **130** is illustrated as a single database, the data store **130** may be implemented by any number and/or type(s) of databases. Further, the data stored in the data store **130** may be in any data format such as, for example, binary data, comma delimited data, tab delimited data, structured query language (SQL) structures, etc.

Further, the central facility **128** illustrated in FIG. **1** contains a processor **132** to process data (e.g., obtained information, generated messages, audio channel characteristics, etc.) acquired by the example media monitor **124**, and to generate one or more report(s) corresponding to the one or more channel characteristic(s) inspected by the example media monitor **124**.

In operation, the block diagram of example system **100** inspects channel characteristics of multichannel audio distributed by media provider(s) **102**, **104**, and/or **106**. The media provider(s) **102**, **104**, and/or **106** distribute the multichannel audio source(s) **108**, **110**, and/or **112** containing one or more watermark(s) embedded by the watermark embedder(s) **114**, **116**, and/or **118**. Alternatively, one or more audio channel identifier watermark(s) **120** can be embedded in the example multichannel audio source **110** by the watermark embedder **116**. One or more of the multichannel audio source(s) **108**, **110**, and/or **112** are further received by the media device **122**. The multichannel audio signal, as received by the media device **122**, is distributed to the example media monitor **124**. An output of the media monitor **124** is further distributed to the central facility **128** via the network **126**. The central facility contains the data store **130** to store one or more output(s) from the media monitor **124**, and processor **132** to process one or more output(s) from the media monitor **124**.

A block diagram further detailing the media monitor **124** of FIG. **1** is illustrated in FIG. **2**. The example media monitor **124** of FIG. **2** can inspect at least one of a channel timing for one or more pair(s) of audio subchannels of the example multichannel audio source(s) **108**, **110**, and/or **112**, and inspect the channel mapping of the example multichannel audio source(s) **108**, **110**, and/or **112** using audio watermarks embedded for the purpose of content identification and/or crediting by the example watermark embedder(s) **114**, **116**, and/or **118**. Additionally or alternatively, the media monitor **124** can inspect the channel mapping of the example multichannel audio source **110** using one or more watermark(s) embedded by the example watermark embedder **116** which contain audio channel identifier **120**.

Looking to FIG. **2**, the illustrated example media monitor **124** of FIG. **2** includes a channel characteristic requester **202**, an audio demultiplexer **204**, a watermark detector **206**, a channel characteristic inspector **208**, a result alerter **210**, audio subchannels **212**, **214**, and **216**, and audio subchannel watermarks **218**, **220**, and **222**.

The example channel characteristic requester **202** of the illustrated example of FIG. **2** is a device that requests one or more characteristic(s) of one or more multichannel audio source(s) **108**, **110**, and/or **112** to be inspected. Characteristics requested can include at least one of audio channel mapping and audio channel timing. In some examples, the example channel characteristic requester **202** will request both audio channel mapping and audio channel timing. Additionally or alternatively, the example channel characteristic requester **202** will request one of audio channel mapping or audio channel timing. Additionally or alternatively, the channel characteristic requester **202** will request neither of audio channel mapping and audio channel timing.

Further, in other such examples, the channel characteristic requester **202** determines one or more media broadcast(s) of interest to be inspected.

Further, in some examples, the characteristics and broadcasts requested by the channel characteristic requester **202** can be determined by a human being (e.g., an operator, a technician, an employee of a media ratings entity, etc.). Additionally or alternatively, the characteristics and broadcasts requested by the channel characteristic requester **202** can be determined by a continuously updating computer architecture. Additionally or alternatively, the characteristics and broadcasts requested by the channel characteristic requester **202** can be constant, determined by at least one of a human being and computer architecture prior to implementation of the media monitor **124**.

The example audio demultiplexer **204** of the illustrated example of FIG. **2** can receive one or more multichannel audio source(s) **108**, **110**, and/or **112** as presented by the example media device **122**, and further obtains one or more audio subchannel(s) of the one or more multichannel audio source(s) **108**, **110**, and/or **112**. As used herein "demultiplex", "demultiplexer", "demultiplexing", "demultiplexers", or any other form of the term "demultiplex" used in this document is defined as the act of/a device capable of electronically obtaining one or more audio subchannel(s) of a multichannel audio signal. Further, "splitting a multichannel audio signal into one or more audio subchannels", as used herein, is defined as the same as "obtaining one or more audio subchannel(s) of a multichannel audio signal."

The example watermark detector **206** of the illustrated example of FIG. **2** detects audio watermarks that were embedded or otherwise encoded by one or more of the watermark embedder(s) **114**, **116**, and/or **118** in the media presented by the media device **122**. For example, the watermark detector **206** may access the audio presented by the media device **122** through physical (e.g., electrical) connections with the speakers of the media device **122**, and/or with an audio line output (if available) of the media device **122**. The audio can additionally or alternatively be captured using a microphone placed in the vicinity of the media device **122**. In some examples, the watermark detector **206** can further decode watermarks and determine the payload data conveyed by the detected watermarks. Further, the decoded watermarks can, in some examples, be distributed for reporting to at least one of the media monitor **124** and the central facility **128**.

The example channel characteristic inspector **208** of the illustrated example of FIG. **2**, described in greater detail below, inspects one or more characteristic(s) of the example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118**, wherein the multichannel audio source(s) **108**, **110**, and/or **112** inspected is(are) demultiplexed into one or more audio subchannel(s) **212**, **214**, and/or **216**, from which the watermark detector **206** detects one or more audio subchannel watermark(s) **218**, **220**, and/or **222**. Further, the one or more channel characteristic(s) inspected is(are) determined by the channel characteristic requester **202**.

The example result alerter **210** of the illustrated example of FIG. **2** is a device that can output an alert regarding a result of the inspection completed by the channel characteristic inspector **208** for viewing by a human being and/or a computer architecture. In some such examples, the example result alerter **210** can be implemented by an alert transmitter (e.g., an alert transmitted via electronic mail (E-Mail), an alert transmitted as a physical letter, an alert transmitted as a text message, an alert transmitted as an instant message (IM), and/or an alert transmitted via Bluetooth, etc.). Further, in some such examples, the example result alerter **210** can distribute an alert to the central facility **128**.

Additionally or alternatively, the example result alerter **210** can be implemented, for example, by one or more display device(s) (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display, a cathode ray tube display (CRT), a touchscreen, a tactile output device, a printer and/or speakers).

The example audio subchannel(s) **212**, **214**, and/or **216** of the illustrated example of FIG. **2** is(are) audio subchannel(s) which is(are) obtained by the audio demultiplexer **204**. Examples of audio subchannel(s) **212**, **214**, and/or **216** from multichannel audio source(s) **108**, **110**, and/or **112** include Left and Right channel (2-channel stereo), Left, Right, and Low Frequency channel (2.1-channel stereo), Left, Right, and Center channel (3-channel stereo), and Left, Right, Center, Left Surround, Right Surround, and Low Frequency channel (5.1 channel surround sound). Note that the above examples are not meant to be limiting, and that any two or more audio subchannels of a multichannel audio source are covered within the scope of this patent.

The example audio subchannel watermark(s) **218**, **220**, and/or **222** of the illustrated example of FIG. **2** is(are) one or more audio watermark(s) embedded in one or more subchannels of a multichannel audio signal acquired over a known sampling period. In some such examples, the audio subchannel watermark(s) **218**, **220**, and/or **222** are only detected. In such examples, only a count of one or more watermark(s) in one or more subchannel(s) of a multichannel audio signal is distributed to the channel characteristic inspector **208**. Additionally or alternatively, payload information of the audio subchannel watermark(s) **218**, **220**, and/or **222** can be decoded. In such an example, one or more content identifying characteristic(s) (e.g., content information, audio channel identification information, timestamps, etc.) is(are) available to the channel characteristic inspector **208**.

In operation, the media monitor **124** inspects at least one of a channel mapping of a multichannel audio signal and a channel timing of a multichannel audio signal by receiving one or more multichannel audio source(s) **108**, **110**, and/or **112** containing audio watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** with the audio demultiplexer **204**. Further, the audio demultiplexer **204** can receive a request for one or more channel characteristic(s) from the channel characteristic requester **202** and one or more audio subchannel(s) **212**, **214** and/or **216** can be obtained by the audio demultiplexer **204**. The audio subchannel(s) **212**, **214**, and/or **216** are distributed to a watermark detector **206** that can at least one of detect and decode audio subchannel watermark(s) **218**, **220**, and/or **222** on audio subchannel(s) **212**, **214**, and/or **216**. The audio subchannel watermark(s) **218**, **220**, and/or **222**, at least one of detected and decoded over the known sampling period, are distributed to the channel characteristic inspector **208**. The channel characteristic inspector **208** can then further inspect a subset of characteristics of a multichannel audio signal using one or more audio subchannel watermark(s) **218**, **220**, and/or **222** in response to a subset of channel characteristic requests from the channel characteristic requester **202**. The output of the channel characteristic inspector **208** is distributed to at least one of the result alerter **210** and the central

facility **128**. In some such examples, the result alerter **210** further distributes a generated alert to the central facility **128**.

Although the example media monitor **124** of FIG. **2** includes one channel characteristic requester **202**, one audio demultiplexer **204**, one watermark detector **206**, one channel characteristic inspector **208**, one result alerter **210**, three audio subchannels **212**, **214**, and **216**, and three audio subchannel watermarks **218**, **220**, and **222**, the media monitor **124** as disclosed herein can be used with any number(s) of channel characteristic requesters **202**, audio demultiplexers **204**, watermark detectors **206**, channel characteristic inspectors **208**, result alerters **210**, audio subchannels **212**, **214**, and/or **216**, and audio subchannel watermarks **218**, **220**, and/or **222**. Further, although the channel characteristic requester **202**, the audio demultiplexer **204**, the watermark detector **206**, the channel characteristic inspector **208**, and result alerter **210** are shown as being implemented within the media monitor **124**, any one or more of these elements can be implemented or otherwise included in the central facility **128**.

A block diagram further detailing the channel characteristic inspector **208** of FIG. **2** is illustrated in FIG. **3**. The channel characteristic inspector **208** can inspect a channel timing for one or more pair(s) of audio subchannels of the example multichannel audio source(s) **108**, **110**, and/or **112**, and inspect a channel mapping of the example multichannel audio source(s) **108**, **110**, and/or **112** using one or more audio watermark(s) embedded by the example watermark embedder(s) **114**, **116**, and/or **118**.

Turning to FIG. **3**, the illustrated example channel characteristic inspector **208** includes watermark managers **302**, **304**, and **306**, a watermark timestamp extractor **308**, a channel mapping inspector **310**, a channel timing inspector **312**, and subchannel watermark content **314**, **316**, and **318**.

The example watermark managers **302**, **304**, and **306** of the illustrated example of FIG. **3** can at least one of analyze and store watermarks, in some such examples audio subchannel watermarks **218**, **220**, and **222**, over the known sampling period. In some such examples, in response to the audio channel identifier **120** being unavailable, the example watermark managers **302**, **304** and/or **306** can analyze and store a count of audio subchannel watermarks **218**, **220**, and/or **222** detected by the example watermark detector **206** over the known sampling period.

Additionally or alternatively, in response to the availability of audio channel identifier **120**, the example watermark manager(s) **302**, **304**, and/or **306** can analyze and distribute payload information related to the audio channel identifier **120** decoded by the watermark detector **206** for the audio subchannel watermark(s) **218**, **220**, and/or **222** for the multichannel audio source **110**.

Further, the example watermark manager(s) **302**, **304**, and/or **306** can distributed at least one of the count of audio subchannel watermark(s) **218**, **220**, and/or **222** and the payload information of audio subchannel watermark(s) **218**, **220**, and/or **222** to at least one of the watermark timestamp extractor **308** and channel mapping inspector **310** in the form of subchannel watermark content **314**, **316**, and/or **318**.

The example watermark timestamp extractor **308** of the illustrated example of FIG. **3** is a device that can extract timestamps from payload information of one or more watermark(s), in some such examples audio subchannel watermark(s) **218**, **220**, and/or **222**, as distributed by the example watermark manager(s) **302**, **304** and/or **306** in the form of subchannel watermark content **314**, **316**, and/or **318** in response to a channel timing request from the channel characteristic requester **202**.

The example channel mapping inspector **310** of the illustrated example of FIG. **3** is a device that can, in response to a channel mapping request from the channel characteristic requester **202**, inspect a channel mapping of one or more audio subchannel(s) **212**, **214**, and/or **216** of one or more multichannel audio source(s) **108**, **110**, and/or **112** including watermarks embedded by watermark embedder(s) **114**, **116**, and/or **118** as presented at the media device **122**. The channel mapping is further based upon one or more audio subchannel watermark(s) **218**, **220**, and/or **222** collected over the known sampling period. In some such examples, in response to the audio channel identifier **120** being unavailable on one or more audio subchannel(s) **212**, **214**, and/or **216** of a multichannel audio signal, the example channel mapping inspector **310** inspects a channel mapping based on a count of one or more audio subchannel watermark(s) **218**, **220**, and/or **222** detected by the watermark detector **206** and further analyzed and distributed by one or more watermark manager(s) **302**, **304**, and/or **306** in the form of subchannel watermark content **314**, **316**, and/or **318** over the known sampling period.

Alternatively, in response to the audio channel identifier **120** being available on each audio subchannel **212**, **214**, and **216** of a multichannel audio signal, the example channel mapping inspector **310** inspects a channel mapping based on the audio channel identifier **120** decoded by the watermark detector **206**, and further analyzed and distributed by each watermark manager **302**, **304**, and **306** in the form of subchannel watermark content **314**, **316**, and/or **318**.

The example channel timing inspector **312** of the illustrated example of FIG. **3** is a device that can, in response to a channel timing request from the channel characteristic requester **202**, inspect a channel timing of one or more audio subchannel(s) **212**, **214**, and/or **216** of one or more multichannel audio source(s) **108**, **110**, and/or **112** including watermarks embedded by watermark embedder(s) **114**, **116**, and/or **118** as presented at the media device **122**. The channel timing is further based upon one or more watermark timestamp(s) of audio subchannel watermark(s) **218**, **220**, and/or **222**, distributed as subchannel watermark content **314**, **316**, and/or **318**, as extracted by the example watermark timestamp extractor **308**. Further, the channel timing inspector **312** inspects a channel timing of a multichannel audio signal by inspecting for a time discrepancy for any one or more watermark timestamp(s) on two or more audio subchannels **212**, **214**, and/or **216** that are meant to be synchronized in time.

The example subchannel watermark content(s) **314**, **316**, and/or **318** is(are) content related to the example audio subchannel watermark(s) **218**, **220**, and/or **222**. In some such examples, the example subchannel watermark content(s) **314**, **316**, and/or **318** can include payload information of the audio subchannel watermark(s) **218**, **220**, and/or **222**. In such examples, the example subchannel watermark content(s) **314**, **316**, and/or **318** can further include the audio channel identifier **120** for one or more of the audio subchannel watermark(s) **218**, **220**, and/or **222**. Additionally or alternatively, the subchannel watermark content(s) **314**, **316**, and/or **318** can include a count of audio subchannel watermark(s) **218**, **220**, and/or **222** detected on audio subchannel(s) **212**, **214**, and/or **216** over a known sampling period.

In operation, the channel characteristic inspector **208** inspects at least one of a channel mapping of a multichannel audio signal and a channel timing of a multichannel audio

signal by receiving one or more audio subchannel watermark(s) **218**, **220**, and/or **222** at one or more watermark manager(s) **302**, **304**, and/or **306**. The one or more watermark manager(s) **302**, **304**, and/or **306** can at least one of analyze and store the audio subchannel watermark(s) **218**, **220**, and/or **222** that is(are) at least one of detected and decoded over the known sampling period. The example watermark manager(s) **302**, **304**, and/or **306** can further distribute information of audio subchannel watermark(s) **218**, **220**, and/or **222**, in the form of subchannel watermark content **314**, **316**, and/or **318**, in response to at least one of a channel mapping and channel timing request from a channel characteristic requester **202**, to at least one of the watermark timestamp extractor **308**, the channel mapping inspector **310** and the channel timing inspector **312**. The channel mapping inspector **310**, in response to a channel mapping request from the channel characteristic requester **202**, inspects a channel mapping of a multichannel audio signal using subchannel watermark content **314**, **316**, and/or **318** which contain(s) at least one of stored and analyzed audio subchannel watermark(s) **218**, **220**, and/or **222**, which are at least one of detected and decoded by the watermark detector **206**, and further distributed by one or more watermark manager(s) **302**, **304**, and/or **306**. The watermark timestamp extractor **308**, in response to a channel timing request from the channel characteristic requester **202**, extracts one or more timestamps from one or more audio subchannel watermark(s) **218**, **220**, and/or **222**, further distributed as subchannel watermark content **314**, **316**, and/or **318** by the watermark manager(s) **302**, **304**, and/or **306**. Further, the watermark timestamp extractor **308** distributes one or more extracted timestamp(s) to the channel timing inspector **312**. The channel timing inspector **312** inspects the channel timing of one or more audio subchannel(s) **212**, **214**, and/or **216** of a multichannel audio signal. Channel mapping results from the channel mapping inspector **310** and channel timing results from the channel timing inspector **312** are combined and distributed to at least one of the result alerter **210** and the central facility **128**.

Although the example channel characteristic inspector **208** of FIG. **3** includes three watermark managers **302**, **304**, and **306**, one watermark timestamp extractor **308**, one channel mapping inspector **310**, one channel timing inspector **312**, and three subchannel watermark contents **314**, **316**, and **318**, the channel characteristic inspector **208** as disclosed herein can be used with any number(s) of watermark managers **302**, **304**, and/or **306**, watermark timestamp extractors **308**, channel mapping inspectors **310**, channel timing inspectors **312**, and subchannel watermark content **314**, **316**, and/or **318**.

FIG. **4** illustrates an example report **400** generated by the example channel characteristic inspector **208** in response to the channel characteristic inspector **208** inspecting one or more characteristic(s) of a multichannel audio signal based on one or more audio subchannel watermark(s) **218**, **220**, and/or **222**. The example report **400** of FIG. **4**, in some such examples being output as a data table, includes the media provider identifier **402** determined from the example system **100**, a channel mapping result **404** determined by the channel mapping inspector **310**, and a channel timing result **406** determined by the channel timing inspector **312**. Thus, the example report **400** indicates (1) which one or more media provider(s) is currently under inspection, (2) a result of a channel mapping inspection via the channel mapping inspector **310**, and (3) a result of the a channel timing inspection via the channel timing inspector **312**. In the illustrated example report **400**, the example data table row **408** includes the media provider identifier **402**, in this example CBS 2 WBBM, the channel mapping result **404**, in this example "audio is okay" (i.e., no channel mapping issue), and the channel timing result **406**, in this example "audio is okay" (i.e., no channel timing issue).

Additionally or alternatively, the example data table row **410** includes the media provider identifier **402**, in this example NBC 5 WMAQ, the channel mapping result **404**, in this example "channel mapping issue" (i.e., an issue with an undetermined channel of the multichannel audio source **108**, **110**, and/or **112**), and the channel timing result **406**, in this example "audio is okay".

Additionally or alternatively, the example data table row **412** includes the media provider identifier **402**, in this example ABC 7 WLS, the channel mapping result **404**, in this example "audio is okay", and the channel timing result **406**, in this example "channel 2 delay" (i.e., the second audio subchannel **214** of a multichannel audio source **108**, **110**, or **112** is delayed compared to one or more of the remaining audio subchannel(s) **212** and/or **216** of the multichannel audio source **108**, **110**, or **112**).

Additionally or alternatively, the example data table row **414** includes the media provider identifier **402**, in this example FOX 32 WFLD, the channel mapping result **404**, in this example "audio is okay" and the channel timing result **406**, in this example "channel N delay" (i.e., an Nth audio subchannel **216** of the multichannel audio source **108**, **110**, or **112** is delayed compared to one or more of the remaining audio subchannel(s) **212** and/or **214** of the multichannel audio source **108**, **110**, or **112**).

Additionally or alternatively, the example data table row **416** includes the media provider identifier **402**, in this example MY 50 WPWR, the channel mapping result **404**, in this example "left channel mapping issue" (i.e., an issue with a left audio channel of the multichannel audio source **110**, determined based on one or more watermark(s) including the audio channel identifier **120**), and the channel timing result **406**, in this example "audio is ok".

Additionally or alternatively, the example data table row **418** includes the media provider identifier **402**, in this example WGN 9, the channel mapping result **404**, in this example "audio is okay", and the channel timing result **406**, in this example "not inspected" (i.e., the channel timing result **406** was not requested by the channel characteristic requester **202**).

Additionally or alternatively, the example data table row **420** includes the media provider identifier **402**, in this example PBS 11 WTTW, the channel mapping result **404**, in this example "not inspected" (i.e., the channel mapping result **404** was not requested by the channel characteristic requester **202**), and the channel timing result **406**, in this example "audio is ok".

Note that the example report **400** described above is not meant to be limiting, and that the example report **400** could additionally or alternatively be output as a word processed document (generated by Microsoft Word, Google Docs, Apple Pages, Notepad, etc.), a comma delineated file (generated by Microsoft Excel, Google Sheets, Apple Numbers, etc.), an automatically generated electronic mail (E-mail) message, and/or any number of readable output mediums.

Further, note that the proposed combination of data table rows **408**, **410**, **412**, **414**, **416**, **418**, and/or **420** in the example report **400** described above is not meant to be limiting, and that any combination and/or permutation of the data table rows **408**, **410**, **412**, **414**, **416**, **418**, and/or **420** within an example report **400** are covered within the scope of this patent.

Furthermore, the data outputs for media provider identifier **402**, channel mapping result **404**, and channel timing result **406** proposed in example data table rows **408**, **410**, **412**, **414**, **416**, **418**, and/or **420** described above are not meant to be limiting, and that any combination and/or permutation of the foregoing data outputs for media provider identifier **402**, channel mapping result **404**, and channel timing result **406** are covered within the scope of this patent.

While an example manner of implementing the example system **100** of FIG. **1** is illustrated in FIGS. **5-8**, one or more of the elements, processes and/or devices illustrated in FIGS. **1-3** may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, the example, media providers **102**, **104**, and/or **106**, the example multichannel audio sources **108**, **110**, and/or **112**, the example watermark embedders **114**, **116**, and/or **118**, the example audio channel identifier **120**, the example media device **122**, the example media monitor **124**, the example network **126**, the example central facility **128** which can, in some examples, contain the example data store **130**, and example processor **132**, the example channel characteristic requester **202**, the example audio demultiplexer **204**, the example watermark detector **206**, the example channel characteristic inspector **208**, the example result alerter **210**, the example audio subchannels **212**, **214**, and/or **216**, the example watermark managers **302**, **304**, and/or **306**, the example watermark timestamp extractor **308**, the example channel mapping inspector **310**, the example channel timing inspector **312**, the subchannel watermark content **314**, **316**, and/or **318**, and/or, more generally, the example system **100** of FIG. **1** may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example media providers **102**, **104**, and/or **106**, the example multichannel audio sources **108**, **110**, and/or **112**, the example watermark embedders **114**, **116**, and/or **118**, the example audio channel identifier **120**, the example media device **122**, the example media monitor **124**, the example network **126**, the example central facility **128** which can, in some examples, contain the example data store **130**, and example processor **132**, the example channel characteristic requester **202**, the example audio demultiplexer **204**, the example watermark detector **206**, the example channel characteristic inspector **208**, the example result alerter **210**, the example audio subchannels **212**, **214**, and/or **216**, the example watermark managers **302**, **304**, and/or **306**, the example watermark timestamp extractor **308**, the example channel mapping inspector **310**, the example channel timing inspector **312**, the subchannel watermark content **314**, **316**, and/or **318** and/or, more generally, the example system **100** could be implemented by one or more analog or digital circuit(s), logic circuits, programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)). When reading any of the apparatus or system claims of this patent to cover a purely software and/or firmware implementation, at least one of the example, media providers **102**, **104**, and/or **106**, the example multichannel audio sources **108**, **110**, and/or **112**, the example watermark embedders **114**, **116**, and/or **118**, the example audio channel identifier **120**, the example media device **122**, the example media monitor **124**, the example network **126**, the example central facility **128** which can, in some examples, contain the example data store **130**, and example processor **132**, the example channel characteristic requester **202**, the example audio demultiplexer **204**, the example watermark detector **206**, the example channel characteristic inspector **208**, the example result alerter **210**, the example audio subchannels **212**, **214**, and/or **216**, the example watermark managers **302**, **304**, and/or **306**, the example watermark timestamp extractor **308**, the example channel mapping inspector **310**, the example channel timing inspector **312**, and the subchannel watermark content **314**, **316**, and/or **318** is/are hereby expressly defined to include a non-transitory computer readable storage device or storage disk such as a memory, a digital versatile disk (DVD), a compact disk (CD), a Blu-ray disk, etc. including the software and/or firmware. Further still, the example system **100** of FIG. **1** may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIG. **1**, and/or may include more than one of any or all of the illustrated elements, processes and devices.

A flowchart representative of example machine readable instructions for implementing the example system **100** of FIG. **1** is shown in FIG. **5**. In this example, the machine readable instructions comprise a program for execution by a processor such as the processor **912** shown in the example processor platform **900** discussed below in connection with FIG. **9**. The program may be embodied in software stored on a non-transitory computer readable storage medium such as a CD-ROM, a floppy disk, a hard drive, a digital versatile disk (DVD), a Blu-ray disk, or a memory associated with the processor **912**, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor **912** and/or embodied in firmware or dedicated hardware. Further, although the example program is described with reference to the flowcharts illustrated in FIGS. **5-8**, many other methods of implementing the example system **100** may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined. Additionally or alternatively, any or all of the blocks may be implemented by one or more hardware circuits (e.g., discrete and/or integrated analog and/or digital circuitry, a Field Programmable Gate Array (FPGA), an Application Specific Integrated circuit (ASIC), a comparator, an operational-amplifier (op-amp), a logic circuit, etc.) structured to perform the corresponding operation without executing software or firmware.

As mentioned above, the example processes of FIGS. **5-8** may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a non-transitory computer and/or machine readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and to exclude transmission media. "Including" and "comprising" (and all forms and tenses thereof) are used herein to be open ended terms. Thus, whenever a claim lists anything following any form of "include" or "comprise" (e.g., comprises, includes, comprising, including, etc.), it is to be understood that additional elements, terms, etc. may be present without falling outside the scope of the corresponding claim. As used herein, when the phrase "at least" is used as the transition term in a preamble of a claim, it is open-ended in the same manner as the term "comprising" and "including" are open ended.

Example machine readable instructions **500** that may be executed to perform channel characteristic inspection for audio watermarking in multichannel audio signals in the example media monitor **124** of FIG. **1** are illustrated in FIG. **5**. With reference to the preceding figures and associated descriptions, the example machine readable instructions **500** of FIG. **5** begin execution at block **502** at which the channel characteristic requester **202** determines which one or more media broadcast(s) of interest, in some such examples distributed by the one or more media provider(s) **102**, **104**, and/or **106**, is(are) currently broadcasting.

At block **504**, the example audio demultiplexer **204** obtains the first uninspected multichannel audio source of example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** from the example media device **122** for inspection, as described above.

At block **506**, the audio demultiplexer **204** demultiplexes the first uninspected multichannel audio source of one or more example multichannel audio source(s) **108**, **110**, and/or **112**, thereby obtaining one or more audio subchannel(s) **212**, **214**, and/or **216** from the first uninspected multichannel audio source of the one or more example multichannel audio source(s) **108**, **110**, and/or **112**.

At block **508**, one or more audio subchannel watermark(s) **218**, **220**, and/or **222** embedded in one or more audio subchannel(s) **212**, **214**, and/or **216** are detected by the watermark detector **206**. Further, in some examples, the watermark detector **206** can decode the one or more audio subchannel watermark(s) **218**, **220**, and/or **222** detected in one or more audio subchannel(s) **212**, **214**, and/or **216**.

At block **510**, further detailed below, channel characteristics of the first uninspected multichannel audio source of one or more example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** presented by the example media device **122** are inspected using the one or more audio subchannel watermark(s) **218**, **220**, and/or **222**.

At block **512**, the channel characteristic requester **202** determines if one or more media broadcast(s) of interest remain uninspected. In response to one or more media broadcast(s) remaining uninspected, processing transfers to block **504**. Conversely, if all media broadcasts of interest are inspected, processing transfers to block **514**.

At block **514**, the channel characteristic requester **202** is further to determine if the media monitor **124** is receiving one or more broadcasts(s) of interest from the media device **122**. In response to the channel characteristic requester **202** determining the media monitor **124** is receiving a media broadcast of interest from the media device **122**, processing returns to block **502**. Conversely, if the media monitor **124** is determined to not be receiving any media broadcasts of interest from the media device **122**, block **514** sets the example machine readable instructions **500** of FIG. **5** to end.

Accordingly, execution of the example machine readable instructions **500** illustrated in FIG. **5** cause the media monitor **124** to determine which media broadcasts of interest are currently broadcasting, and further obtain, isolate, and detect one or more watermark(s) embedded in one or more audio subchannel(s) of the first uninspected media broadcast of interest, and inspect one or more channel characteristic(s) of the embedded watermarks for the duration of one or more media broadcast(s) of interest.

Example machine readable instructions that may be executed to inspect channel characteristics (FIG. **5**, block **508**) of multichannel audio signals utilizing the example channel characteristic inspector **208** of FIG. **3** are illustrated in FIG. **6**. With reference to the preceding figures and associated descriptions, the example method of FIG. **6** begin execution at block **602** at which at least one of a watermark timestamp extractor **308**, channel mapping inspector **310**, and channel timing inspector **312** receive at least one of a channel mapping inspection request and a channel timing inspection request from the channel characteristic requester **202**, as described above.

At block **604**, the example watermark manager(s) **302**, **304**, and/or **306** receive(s) one or more audio subchannel watermark(s) **218**, **220**, and/or **222** from the example watermark detector **206**.

Further, at block **606**, the example watermark manager(s) **302**, **304**, and/or **306** distribute(s) one or more subchannel watermark content(s) **314**, **316**, and/or **318**. In some such examples, watermark payload information has not been decoded and the example watermark manager(s) **302**, **304**, and/or **306** distributes(s) a count of watermarks detected by the watermark detector **206** on one or more audio subchannels **212**, **214**, and/or **216** of a multichannel audio signal in the form of subchannel watermark content(s) **314**, **316**, and/or **318**. In other such examples, watermark payload information has been decoded and the example watermark manager(s) **302**, **304**, and/or **306** distribute(s) one or more elements of payload information decoded by the watermark detector **206** on one or more audio subchannels **212**, **214**, and/or **216** of a multichannel audio signal in the form of subchannel watermark content(s) **314**, **316**, and/or **318**.

At block **608**, the channel characteristic inspector **208** determines whether channel mapping information is requested by the channel characteristic requester **202**. In response to identifying channel mapping information as requested, processing transfers to block **610**. Alternatively, in response to identifying channel mapping information as not requested, processing transfers to block **612**.

At block **610**, further detailed below, the channel mapping of one or more example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** and distributed by the example media provider(s) **102**, **104**, and/or **106** presented by example media device **122** are inspected utilizing the one or more subchannel watermark content(s) **314**, **316**, and/or **318**.

At block **612**, the channel characteristic inspector **208** determines whether channel timing information is requested by the channel characteristic requester **202**. In response to identifying channel timing information as requested, processing transfers to block **614**. Alternatively, in response to identifying channel timing information as not requested, the example method of FIG. **6** is completed and processing returns to block **510** of the example machine readable instructions **500** of FIG. **5**.

At block **614**, in response to block **612** identifying channel timing information as requested, one or more watermark timestamp(s) are extracted from one or more subchannel watermark content(s) **314**, **316**, and/or **318** by the example watermark timestamp extractor **308**.

At block **616**, further detailed below, the channel timing of one or more example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** and presented by example media device **122** are inspected using the one or more subchannel watermark content(s) **314**, **316**, and/or **318**.

Accordingly, execution of the example method illustrated in FIG. **6** cause the channel characteristic inspector **208** to obtain a request for one or more channel characteristic

inspection(s), receive and store audio watermark content, determine if channel mapping information is requested, inspect channel mapping in response to channel mapping information being requested, determine if channel timing information is requested, and extract one or more timestamp(s) from one or more embedded watermark(s) and further inspect channel timing in response to channel timing information being requested. After completion of at least one of block **612** and block **616**, the example method of FIG. **6** returns processing to block **512** of the example machine readable instructions **500** of FIG. **5**.

Example machine readable instructions that may be executed to perform channel mapping inspection (FIG. **6**, block **610**) for audio watermarking in multichannel audio signals in the example channel mapping inspector **310** of FIG. **3** are illustrated in FIG. **7**A-**7**B. With reference to the preceding figures and associated descriptions, the example method of FIG. **7** begin execution at block **702** at which the example channel mapping inspector **310** receives one or more subchannel watermark content(s) **314**, **316**, and/or **318** from one or more watermark manager(s) **302**, **304**, and/or **306**, as described above.

At block **704**, the channel mapping inspector **310** determines whether audio channel identifier **120** is embedded in each audio subchannel of a multichannel audio signal. In response to identifying the audio channel identifier **120** is embedded on each audio subchannel of a multichannel audio signal, processing transfers to block **724**. Alternatively, in response to identifying the audio channel identifier **120** is not embedded on each audio subchannel of a multichannel audio signal, processing transfers to block **708**.

At block **708**, in response to identifying the audio channel identifier **120** is not embedded on each audio channel of multichannel audio signal, the channel mapping inspector **310** determines the channel mapping of one or more example multichannel audio source(s) **108**, **110**, and/or **112** containing watermarks embedded by the example watermark embedder(s) **114**, **116**, and/or **118** and presented at the example media device **122** utilizing the count of one or more audio subchannel watermark(s) **218**, **220**, and/or **222** as distributed by the example watermark manager(s) **302**, **304**, and/or **306** in the form of subchannel watermark content(s) **314**, **316**, and/or **318**. In some such examples, the channel mapping inspector **310** determining the channel mapping further includes comparing a count of watermarks received in the center channel with a count of watermarks received in each of the left channel and right channel of a multichannel audio signal. In response to identifying that the count of watermarks received in the center channel is similar to the count of watermarks received in each of the left channel and right channel of a multichannel audio signal, processing transfers to block **714**. Alternatively, in response to identifying that the count of watermarks received in the center channel is not similar to the count of watermarks received in each of the left channel and right channel of a multichannel audio signal, processing transfers to block **710**.

At block **710**, the channel mapping inspector **310** sets a flag indicating that a possible channel mapping issue exists. Further, block **712** stores the flag set by block **710** in the channel mapping inspector **310**.

At block **714**, the channel mapping inspector **310** compares a count of watermarks detected in the center channel of a multichannel audio signal with a count of watermarks detected in each of a left surround and right surround channel of a multichannel audio signal. In response to identifying that the count of watermarks in at least one of the left surround channel and right surround channel is insignificant when compared to the count of watermarks detected in the center channel of a multichannel audio signal, processing transfers to block **718** where the channel mapping inspector **310** sets a flag indicating that the audio is okay. Alternatively, in response to identifying that the count of watermarks in at least one of the left surround channel and right surround channel is significant when compared to the count of watermarks detected in the center channel of a multichannel audio signal, processing transfers to block **716** where the channel mapping inspector **310** sets a flag indicating that a channel mapping issue exists.

At block **720**, in response to identifying the audio channel identifier **120** is embedded on each audio channel of a multichannel audio signal, the channel mapping inspector **310** is to obtain the audio channel identifier **120** for one or more watermark(s) as distributed by subchannel watermark content(s) **314**, **316**, and/or **318**.

At block **722**, in response to obtaining the audio channel identifier **120** from the subchannel watermark content(s) **314**, **316**, and/or **318**, the channel mapping inspector **310** determines whether the channel 1 identifier watermark of the audio channel identifier **120** is properly embedded in channel 1. In response to identifying the channel 1 watermark is embedded in channel 1, processing transfers to block **726**. Alternatively, in response to identifying the channel 1 watermark is not embedded in channel 1 (e.g., the channel 1 watermark is not embedded in any channel of a multichannel audio signal, the channel 1 watermark is embedded in channel 2 of a multichannel audio signal, etc.), processing transfers to block **724**.

At block **724**, the channel mapping inspector **310** determines whether the channel 2 identifier watermark of the audio channel identifier **120** is properly embedded in channel 2. Upon completion of inspection, processing transfers to block **728**.

At block **726**, the channel mapping inspector **310** determines whether the channel 2 identifier watermark of the audio channel identifier **120** is properly embedded in channel 2. In response to identifying the channel 2 watermark is embedded in channel 2, processing transfers to block **730**. Alternatively, in response to identifying the channel 2 watermark is not embedded in channel 2 (e.g., the channel 2 watermark is not embedded in any channel of a multichannel audio signal, the channel 2 watermark is embedded in channel N of a multichannel audio signal, etc.), processing transfers to block **728**.

At block **728**, the channel mapping inspector **310** determines whether the channel N identifier watermark of the audio channel identifier **120** is properly embedded in channel N. Upon completion of inspection, processing transfers to block **732**.

At block **730**, the channel mapping inspector **310** determines whether the channel N identifier watermark of the audio channel identifier **120** is properly embedded in channel N. In response to identifying the channel N watermark is embedded in channel N, processing transfers to block **730**. Alternatively, in response to identifying the channel N watermark is not embedded in channel N (e.g., the channel N watermark is not embedded in any channel of a multichannel audio signal, the channel N watermark is embedded in channel 1 of a multichannel audio signal, etc.), processing transfers to block **732**.

At block **732**, the channel mapping inspector **310** sets a flag indicating a channel mapping issue exists in response to at least one of the channel 1, channel 2, and channel N identifier watermark(s) not being embedded in the channel respective to the watermark. Further, in some such

examples, the channel mapping inspector **310** stores the individual results of the determination(s) of at least one of block(s) **722**, **724**, **726**, **728**, and **730** and can, in such examples, further indicate which one or more subchannel(s) of a multichannel audio signal are mapped improperly. Upon completion of setting the channel mapping issue flag, processing transfers to block **738**.

At block **734**, the channel mapping inspector **310**, in response to each of channel 1, channel 2, and channel N of the multichannel audio signal containing a proper audio channel identifier watermark, sets a flag indicating the audio channel mapping is okay and processing transfers to block **738**.

At block **738**, the channel mapping inspector **310** sets a flag indicating the compiled results of the channel mapping inspection. In some such examples, the compiled results can read "Audio is okay". Alternatively, the compiled results can read "Channel mapping issue". Alternatively, the compiled results can read "Possible channel mapping issue; audio is okay". Alternatively, the compiled results can read "Channel mapping issue; channel 2". Additionally or alternatively, note that the above examples are not meant to be limiting, and that any combination and/or permutation of the foregoing audio channel mapping inspection flags are covered in the scope of this patent.

Accordingly, execution of the example machine readable instructions illustrated in FIG. **7** cause the example channel mapping inspector **310** to receive one or more audio watermark(s) isolated by audio subchannel, determine if audio channel identifier watermarks are available, inspect the channel mapping using audio channel identifier watermarks in response to the availability of audio channel identifier watermarks, inspect the channel mapping using a count of audio watermarks in response to the unavailability of audio channel identifier watermarks, and compile the results of the channel mapping inspection. After completion of block **738**, the example machine readable instructions of FIG. **7**A-**7**B returns processing to block **612** of the example method of FIG. **6**.

Example machine readable instructions that may be executed to inspect channel timing (FIG. **6**, block **616**) for audio watermarking in multichannel audio signals in the example channel timing inspector **312** of FIG. **3** are illustrated in FIG. **8**. With reference to the preceding figures and associated descriptions, the example method of FIG. **8** begins execution at block **802** at which the example channel timing inspector **312** receives one or more watermark timestamp(s), isolated by audio subchannel, from the example watermark timestamp extractor **308**, as described above.

At block **804**, the channel timing inspector **312** inspects one or more watermark timestamp(s) output by the watermark timestamp extractor **308**. Further, the channel timing inspector **312** inspects for a time discrepancy (i.e., two subchannels not substantially synchronized in time) between one or more watermark timestamp(s) embedded on a pair of audio subchannels intended to be synchronized in time. This process is repeated for a subset of pairs of audio subchannels

In response to block **804** determining that a time discrepancy exists for one or more watermark timestamp(s) isolated by subchannel on a pair of audio subchannels intended to be embedded substantially synchronized in time for any one or more pair(s) of audio subchannels, indicating at block **806**, with the channel timing inspector **312**, that an audio channel timing issue exists.

In response to block **804** determining that a time discrepancy does not exist for one or more watermark timestamp(s) isolated by subchannel on a pair of audio subchannels intended to be embedded synchronized in time for each of a subset of pairs of audio subchannels, indicating at block **808**, with the channel timing inspector **312**, that the audio is okay.

Accordingly, execution of the example method illustrated in FIG. **8** cause the example channel timing inspector **312** to receive watermark timestamps isolated by audio subchannel, inspect for a time discrepancy between any one or more pair(s) of audio subchannels of a multichannel audio signal, and determine and further indicate if a channel timing issue exists. Upon completion of at least one of block **806** and block **808**, the example method of FIG. **8** returns the processing to the end of the example method of FIG. **6**, further returning the processing to block **510** of the example machine readable instructions **500** of FIG. **5**.

FIG. **9** is a block diagram of an example processor platform **900** capable of executing the instructions of FIGS. **5**-**8** to implement the apparatus of FIGS. **1**-**3**. The processor platform **900** can be, for example, a server, a personal computer, a mobile device (e.g., a cell phone, a smart phone, a tablet such as an iPad™), a personal digital assistant (PDA), an Internet appliance, a DVD player, a CD player, a digital video recorder, a Blu-ray player, a gaming console, a personal video recorder, a set top box, or any other type of computing device.

The processor platform **900** of the illustrated example includes a processor **912**. The processor **912** of the illustrated example is hardware. For example, the processor **912** can be implemented by one or more integrated circuits, logic circuits, microprocessors or controllers from any desired family or manufacturer. The hardware processor may be a semiconductor based (e.g., silicon based) device. In this example, the processor implements the media monitor **124** which can, in some such examples, include the channel characteristic requester **202**, the audio demultiplexer **204**, the watermark detector **206**, the channel characteristic inspector **208** which can, in some such examples, include the one or more watermark manager(s) **302**, **304**, and/or **306**, the watermark timestamp extractor **308**, the channel mapping inspector **310**, and the channel timing inspector **312**, and the result alerter **210**.

The processor **912** of the illustrated example includes a local memory **913** (e.g., a cache). The processor **912** of the illustrated example is in communication with a main memory including a volatile memory **914** and a non-volatile memory **916** via a bus **918**. The volatile memory **914** may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. The non-volatile memory **916** may be implemented by flash memory and/or any other desired type of memory device. Access to the main memory **914**, **916** is controlled by a memory controller.

The processor platform **900** of the illustrated example also includes an interface circuit **920**. The interface circuit **920** may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a PCI express interface.

In the illustrated example, one or more input devices **922** are connected to the interface circuit **920**. The input device(s) **922** permit(s) a user to enter data and/or commands into the processor **912**. The input device(s) can be implemented by, for example, an audio sensor, a microphone, a camera (still or video), a keyboard, a button, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

One or more output devices **924** are also connected to the interface circuit **920** of the illustrated example. The output devices **924** can be implemented, for example, by display devices (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display, a cathode ray tube display (CRT), a touchscreen, a tactile output device, a printer and/or speakers). The interface circuit **920** of the illustrated example, thus, typically includes a graphics driver card, a graphics driver chip and/or a graphics driver processor.

The interface circuit **920** of the illustrated example also includes a communication device such as a transmitter, a receiver, a transceiver, a modem and/or network interface card to facilitate exchange of data with external machines (e.g., computing devices of any kind) via a network **926** (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system, etc.).

The processor platform **900** of the illustrated example also includes one or more mass storage devices **928** for storing software and/or data. Examples of such mass storage devices **928** include floppy disk drives, hard drive disks, compact disk drives, Blu-ray disk drives, RAID systems, and digital versatile disk (DVD) drives.

The coded instructions **932** of FIGS. **5-8** may be stored in the mass storage device **928**, in the volatile memory **914**, in the non-volatile memory **916**, and/or on a removable tangible computer readable storage medium such as a CD or DVD.

From the foregoing, it will be appreciated that example methods, apparatus and articles of manufacture have been disclosed that inspect characteristics of multichannel audio using watermarking techniques.

Although certain example methods, apparatus, and articles of manufacture have been disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the claims of this patent.

What is claimed is:

1. An apparatus to determine a mapping characteristic of a multichannel audio signal, the apparatus comprising:

an audio demultiplexer to obtain an audio subchannel of the audio signal;

a watermark detector to detect an embedded watermark in the audio subchannel of the multichannel audio signal;

a channel characteristic inspector to determine the mapping characteristic of the audio subchannel of the multichannel audio signal based on the embedded watermark, the channel characteristic inspector further to:

determine a quantity of embedded watermarks in the audio subchannel; and

identify an improper mapping characteristic based on the quantity of embedded watermarks in the audio subchannel; and

a result alerter to distribute an alert when the improper mapping characteristic of the audio subchannel of the multichannel audio signal is identified.

2. The apparatus of claim **1**, wherein the channel characteristic inspector further includes a channel mapping inspector to determine an availability of an audio channel identifier watermark in the audio subchannel of the multichannel audio signal.

3. The apparatus as defined in claim **2**, wherein the channel mapping inspector is further to, when the audio channel identifier watermark is available:

identify the improper mapping characteristic when the audio subchannel of the multichannel audio signal does not contain a proper audio channel identifier watermark; and

determine the mapping characteristic is correct, when the audio subchannel of the multichannel audio signal contains the proper audio channel identifier watermark.

4. The apparatus of claim **2**, wherein when the audio channel identifier watermark is unavailable:

the audio demultiplexer is further to:

determine the audio subchannel is a first audio subchannel of the multichannel audio signal;

obtain a second audio subchannel of the multichannel audio signal; and

obtain a third audio subchannel of the multichannel audio signal;

the watermark detector is further to detect an embedded watermark in each of the second and third audio subchannels of the multichannel audio signal;

the channel characteristic inspector further includes a watermark manager to determine a quantity of embedded watermarks in each of the first, second and third audio subchannels; and

the channel mapping inspector is further to:

identify a possible improper mapping characteristic when the quantity of embedded watermarks in at least one of the first and second audio subchannels is dissimilar;

identify the improper mapping characteristic when the quantity of embedded watermarks in the third audio subchannel is significant compared to the quantity of embedded watermarks in the first audio subchannel; and

determine the mapping characteristic is correct when the quantity of embedded watermarks in the third audio subchannel is insignificant compared to the quantity of embedded watermarks in the first audio subchannel.

5. A method of inspecting a mapping characteristic of a multichannel audio signal, the method comprising:

obtaining an audio subchannel of the multichannel audio signal;

detecting an embedded watermark in the audio subchannel of the multichannel audio signal;

determining the mapping characteristic of the audio subchannel of the multichannel audio signal based on the embedded watermark, the determining further including:

determining a quantity of embedded watermarks in the audio subchannel; and

identifying an improper mapping characteristic based on the quantity of embedded watermarks in the audio subchannel; and

in response to identifying the improper mapping characteristic of the audio subchannel of the multichannel audio signal, distributing an alert.

6. The method of claim **5**, wherein the mapping characteristic of the audio subchannel of the multichannel audio signal can further be stored in a facility in response to at least one of a presence of an issue with the characteristic of the audio subchannel of the multichannel audio signal or an absence of an issue with the characteristic of the audio subchannel of the multichannel audio signal.

7. The method of claim **5**, further including determining an availability of an audio channel identifier watermark in the audio subchannel of the multichannel audio signal.

8. The method of claim 7, wherein determining the channel mapping further includes, in response to the availability of the audio channel identifier watermark embedded in the audio subchannel of the multichannel audio signal:

identifying, in response to the audio subchannel of the multichannel audio signal not containing a proper audio channel identifier watermark, the improper mapping characteristic; and

determining, in response to the audio subchannel of the multichannel audio signal containing the proper audio channel identifier watermark, the mapping characteristic is correct.

9. The method of claim 7, wherein determining the channel mapping further includes, in response to an unavailability of the audio channel identifier watermark embedded in the audio subchannel of the multichannel audio signal:

the audio subchannel is a first audio subchannel of the multichannel audio signal;

obtaining a second audio subchannel of the multichannel audio signal;

obtaining a third audio subchannel of the multichannel audio signal;

detecting an embedded watermark in each of the second and third audio subchannels of the multichannel audio signal;

determining a quantity of embedded watermarks in each of the first, second and third audio subchannels;

identifying, in response to the quantity of embedded watermarks in at least one of the first and second audio subchannels being dissimilar, a possible improper mapping characteristic;

identifying, in response to the quantity of embedded watermarks in the third audio subchannel being significant when compared to the quantity of embedded watermarks in the first audio subchannel, the improper mapping characteristic; and

determining, in response to the quantity of embedded watermarks in the third audio subchannel being insignificant compared to the quantity of embedded watermarks in the first audio subchannel, the mapping characteristic is correct.

10. A non-transitory machine readable storage medium comprising machine readable instructions which, when executed, cause a machine to at least:

obtain, with a processor, an audio subchannel of a multichannel audio signal;

detect, with the processor, an embedded watermark in the audio subchannel of the multichannel audio signal;

determine, with the processor, a characteristic of the audio subchannel of the multichannel audio signal based on the embedded watermark, the determining further including:

determining a quantity of embedded watermarks in the audio subchannel; and

identifying an improper mapping characteristic based on the quantity of embedded watermarks in the audio subchannel; and

distribute, with the processor, an alert when the improper mapping characteristic of the audio subchannel of the multichannel audio signal is identified.

11. The storage medium of claim 10, wherein the mapping characteristic of the audio subchannel of the multichannel audio signal can further be stored in a facility in response to at least one of a presence of an issue with the characteristic of the audio subchannel of the multichannel audio signal or an absence of an issue with the characteristic of the audio subchannel of the multichannel audio signal.

12. The storage medium of claim 10, wherein the instructions, when executed, cause the machine to determine an availability of an audio channel identifier watermark in the audio subchannel of the multichannel audio signal.

13. The storage medium of claim 12, wherein the instructions, when executed, further cause the machine to, when the audio channel identifier watermark is available:

identify the improper mapping characteristic when the audio subchannel of the multichannel audio signal does not contain a proper audio channel identifier watermark; and

determine the mapping characteristic is correct, when the audio subchannel of the multichannel audio signal contains the proper audio channel identifier watermark.

14. The storage medium of claim 12, wherein the instructions, when executed, cause the machine to, when the audio channel identifier watermark is unavailable:

determine the audio subchannel is a first audio subchannel of the multichannel audio signal;

obtain a second audio subchannel of the multichannel audio signal;

obtain a third audio subchannel of the multichannel audio signal;

detect an embedded watermark in each of the second and third audio subchannels of the multichannel audio signal;

determine a quantity of embedded watermarks in each of the second and third audio subchannels;

identify a possible improper mapping characteristic when the quantity of embedded watermarks in at least one of the first and second audio subchannels is dissimilar;

identify the improper mapping characteristic when the quantity of embedded watermarks in the third audio subchannel is significant when compared to the quantity of embedded watermarks in the first audio subchannel; and

determine the mapping characteristic is correct when the quantity of embedded watermarks in the third audio subchannel is insignificant compared to the quantity of embedded watermarks in the first audio subchannel.

15. An apparatus to determine a timing characteristic of a multichannel audio signal, the apparatus comprising:

an audio demultiplexer to obtain first and second audio subchannels of the multichannel audio signal;

a watermark detector to detect a first embedded watermark associated with the first audio subchannel and a second embedded watermark associated with the second audio subchannel;

a channel characteristic inspector to determine the timing characteristic of the multichannel audio signal, the channel characteristic inspector further to:

extract a first timestamp from the first embedded watermark and a second timestamp from the second embedded watermark; and

identify an improper timing characteristic based on a comparison of a first time associated with the first timestamp to a second time associated with the second timestamp; and

a result alerter to distribute an alert when the improper timing characteristic of the audio subchannel of the multichannel audio signal is identified.

16. The apparatus of claim 15, wherein

the channel characteristic inspector further includes:

a watermark timestamp extractor to extract the first timestamp from the first embedded watermark of the first audio subchannel and the second timestamp

from the second embedded watermark of the second audio subchannel of the multichannel audio signal; and

a channel timing inspector to:

identify the improper timing characteristic, when a time discrepancy exists for the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels; and

determine the timing characteristic is correct, when the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels contain synchronized timestamps.

17. A method of inspecting a timing characteristic of a multichannel audio signal, the method comprising:

obtaining first and second audio subchannels of the multichannel audio signal;

detecting a first embedded watermark associated with the first audio subchannel and a second embedded watermark associated with the second audio subchannel;

determining the timing characteristic of the multichannel audio signal, the determining further including:

extracting a first timestamp from the first embedded watermark and a second timestamp from the second embedded watermark; and

identifying an improper timing characteristic based on a comparison of a first time associated with the first timestamp to a second time associated with the second timestamp; and

in response to identifying the improper timing characteristic of the audio subchannel of the multichannel audio signal, distributing an alert.

18. The method of claim **17**, further including

identifying, using the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels, in response to a time discrepancy existing, the improper timing characteristic; and

determining, using the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels, in response to the first and second embedded watermarks in the first and second audio subchannels containing synchronized timestamps, the timing characteristic is correct.

19. A non-transitory machine readable storage medium comprising machine readable instructions which, when executed, cause a machine to at least:

obtain, with a processor, first and second audio subchannels of a multichannel audio signal;

detect, with the processor, a first embedded watermark associated with the first audio subchannel and a second embedded watermark associated with the second audio subchannel;

determine, with the processor, a timing characteristic of the multichannel audio signal, the determining further including:

extracting a first timestamp from the first embedded watermark and a second timestamp from the second embedded watermark; and

identifying an improper timing characteristic based on a comparison of a first time associated with the first timestamp to a second time associated with the second timestamp; and

distribute, with the processor, an alert when the timing characteristic of the audio subchannel of the multichannel audio signal is identified.

20. The storage medium of claim **19**, wherein the instructions, when executed, further cause the machine to:

identify the improper timing characteristic, when a time discrepancy exists for the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels; and

determine the timing characteristic is correct, when the first and second timestamps extracted from the first and second embedded watermarks in the first and second audio subchannels contain synchronized timestamps.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,242,680 B2
APPLICATION NO. : 15/612960
DATED : March 26, 2019
INVENTOR(S) : Khaldun Karazoun

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 24, Line 23 (Claim 4): Replace “the first, second and third” with --the second and third--

Column 25, Line 27 (Claim 9): Replace “the first, second and third” with --the second and third--

Signed and Sealed this
Twenty-eighth Day of April, 2020

Andrei Iancu
Director of the United States Patent and Trademark Office